SCIENCE TEACHER'S WORLD

or Teachers of Science
PLEASE ROUTE TO:

Teacher's edition of SCIENCE WORLD March 2, 1960

Using *Science World* in Your Teaching

The Restless Ocean (pp. 5-8)

Earth Science Topics: Atmospheric currents, ocean currents
General Science Topics: Weather and climate
Biology Topic: Ecology
Physics Topics: Density, specific gravity
Vocational Guidance: Oceanography

About This Article

Every lad and lassie knows
That a fluid flows and a current goes

But when it comes to the ocean of fluid air and the oceans of fluid water, can they explain the patterns of flow of the earth's atmosphere? Do they comprehend how these patterns impress themselves upon the oceans like a cosmic hydromatic gear driven by the power of the sun? Do they have some conception of the vast currents that flow within the oceans both horizontally and vertically? Are they aware of how these currents affect, not only life in the sea, but life on the exposed continents? Do they know that phenomena such as these are studied not only in the "field," but also in the laboratory? They may have heard of soaring birds; but have they ever heard of soaring *submarines*? Do they know what a *gyre* is?—a bathythermograph—a Nansen bottle? Have they ever thought of anybody dropping two thousand pop bottles into the sea?

If not, Mr. Tozer's article will be an intellectual and emotional treat. It will reveal to them some of the methods used in oceanography, increase their awareness of living on a rotating planet, and enhance their appreciation of how profoundly the sun influences the fluids of the earth.

Topics for Class Discussion

1. "A bottle dropped off the North Carolina coast might float far out into the Atlantic and eventually return to the North Carolina coast"
   (a) In which direction would it float?
   (b) About how fast would it travel?
   (c) How would the route of a floating object in the south Atlantic differ from that of a bottle in the north Atlantic?
2. Describe what happens when cold ocean currents and warm ocean currents meet.
3. How do ocean currents affect life in the sea? How do they affect climates of coastal regions?
4. In what two ways do wind currents produce ocean currents?
5. How may we account for the directions taken by the north Atlantic Gulf Stream?
6. Describe the method by which Dr. William von Arx studies the Gulf Stream.
7. How do oceanographers measure the temperature, salinity, and flow of water that sometimes runs six miles deep?

Machines That Listen (pp. 12-15)

General Science Topic: Sound
Physics Topics: Sound, electronics
Biology Topic: How we hear
Vocational Guidance: Electronic Engineering

About This Article

This article explains how the sound spectrograph works, and tells how this instrument has been used by Bell Telephone engineers to design "Audrey" (Automatic Digit Recognizer)—a machine that can hear and recognize ten numbers and dial your phone when you speak the telephone number you want. The author goes on to compare this machine with the human hearing apparatus. He then describes how the sound spectrograph is used in "voice-printing"—a record as discriminative of individuality as fingerprinting.

Now, if sounds can be analyzed and recorded electronically, they should be capable of being *synthesized* from electronic instructions. In other words, if a machine can listen and record, it can be made to talk. The author describes some experimental work at the Bell Telephone Laboratories to develop such a machine; it is called the *Vocoder*. More successful, however, has been the invention of a machine that "sings" according to instructions fed into it in the form of electronic signals. The name of this machine is the *Electronic Music Synthesizer*. This machine can not only produce any quality of tone in any pitch, but it is capable of accelerandos, portamentos, vibratos, diminuendos, etc. When all is said and done, however, it takes a ***human being*** to compose and interpret meaningful music.

[The sound spectrograph and other experimental devices used in the study of sound will be demonstrated in "The Alphabet Conspiracy," the Bell System Science Series program about language. Time: Sunday, March 20, at 6 p.m.]

Topics for Class Discussion

1. Compare a sound spectrograph to a light spectrograph.
2. How does a sound spectrograph work?
3. Describe the machine named "Audrey."
4. Compare the mechanism of Audrey to the mechanism of human hearing.
5. Describe the uses of "voiceprinting."
6. How does the talking machine, "Vocodor," work?
7. How does the *Electronic Music Synthesizer* work?
8. What are the potentialities and the limitations of the *Electronic Music Synthesizer?*

Atomic Explorer (p. 20)

Physics Topic: Nucleonics

Vocational Guidance: Nuclear Physicist

About This Article

Tradition in America and Western Europe have hitherto made physics a *man's* science. The present shortage of physicists and physics teachers has brought the realization that this cultural peculiarity is causing us to neglect a great reservoir of talent and ability—the latent *woman*-power in science. This article is therefore most timely. It is about a young and attractive woman who is a first-rate physicist actively engaged in one of the most "scientific" of scientific pursuits—the study of fundamental nuclear particles.

Perhaps some of the bright girls in your class will be brought around to identify themselves with this woman physicist. For both boys and girls the article might serve to break down traditional prejudice against women in physical science. At the same time, it will serve to give physics classes a glimpse into the methods and apparatus used in the study of sub-atomic particles. The Bevatron is mentioned, the liquid hydrogen bubble chamber is described, and an account is given of how nuclear particles are identified by the tracks they make and, more remarkably, by tracks they *fail* to make—tracks inferred from decay-patterns.

Some Review Questions

1. How much energy is required to produce a beam of antiprotons?
2. How is a stream of antiprotons directed into a bubble chamber?
3. What is the effect of a collision between an antiproton and a hydrogen atom?
4. How is hydrogen made to act as a liquid in the hydrogen bubble chamber?
5. Explain how visible tracks are formed in a hydrogen bubble chamber.
6. If lambda and antilambda particles leave no tracks in a bubble chamber, how is it known that they exist?

Tomorrow's Scientists (pp. 21-24)

Settle—Radiation Induced Mutations

How felicitous! A young eager investigator working in partnership with a mature research scientist. In the case of Wayne Settle, the scientist, Dr. T. J. Osborne, provided an environmental treatment of seeds that no high school teacher could be expected to provide since it involved Cobalt-60, a dangerously powerful gamma-ray source. The student, in turn, provided the industry, patience, and perseverence in planting the seeds, in cultivating the plants, in meticulously observing and recording possible effects of the various doses of radiation to which the seeds had been subjected. He noted growth-rates, morphological peculiarities, flowering and ripening dates—even insect damage. As is the case with every scientist, Settle came away from his work with the unknown beckoning him on to further research. He wants to obtain the next generation, and hopes to be able to make a study of the chromosomes.

This article might well be assigned to a biology class for study in conjunction with the study of Muller's original experiments in producing X ray mutations in fruit flies.

Picker—Aerodynamic Flow Studies

Objects traveling through air at the speed of sound (Mach I) or faster, experience air as viscous as liquid. Hence the effects of air on objects traveling at such speeds can be studied by observing the objects in a stream of water. But to get a stream of water as smooth as air is more easily said than done. Harvey Picker describes in detail the difficulties he encountered and how he overcame them one by one to accomplish this feat. He next solved the problem of measuring the flow and even the more difficult problem of photographing the flow in the form of streamlines and shadowgraphs. He can now observe effects that an airplane would experience traveling at more than a thousand miles an hour.

This article would make good reading not only for the student interested in airplanes but also for bright students in physics classes. —Z. S.

Genetics (pp. 9, 11)

Biology Topics: Mendelianism, plant and animal breeding, mutation, chromosomes, genes

Chemistry Topics: Proteins, enzymes, enzyme specificity, catalysis

Physics Topics: Radioactivity, radioactive isotopes, roentgen rays, radiation hazards

Mathematics Topics: Statistics, probability, information theory

About This Article

This article, following the two related articles on *Embryology* and *Cell Differentiation* will expand the student's understanding of the regularities of development.

Science stems directly from man's capacity to wonder and grow excited about the possibilities of finding explanations for the remarkable regularities in nature. Yet, to be productive, the wonder that leads to scientific knowledge must be controlled and followed quickly by tentative explanations, providing a suitable basis for experimental work.

The classical work of Mendel and Morgan, when contrasted with the researches of Beadle and Tatum, make a nice distinction between empiricism and experimental work done in a theoretical frame of reference.

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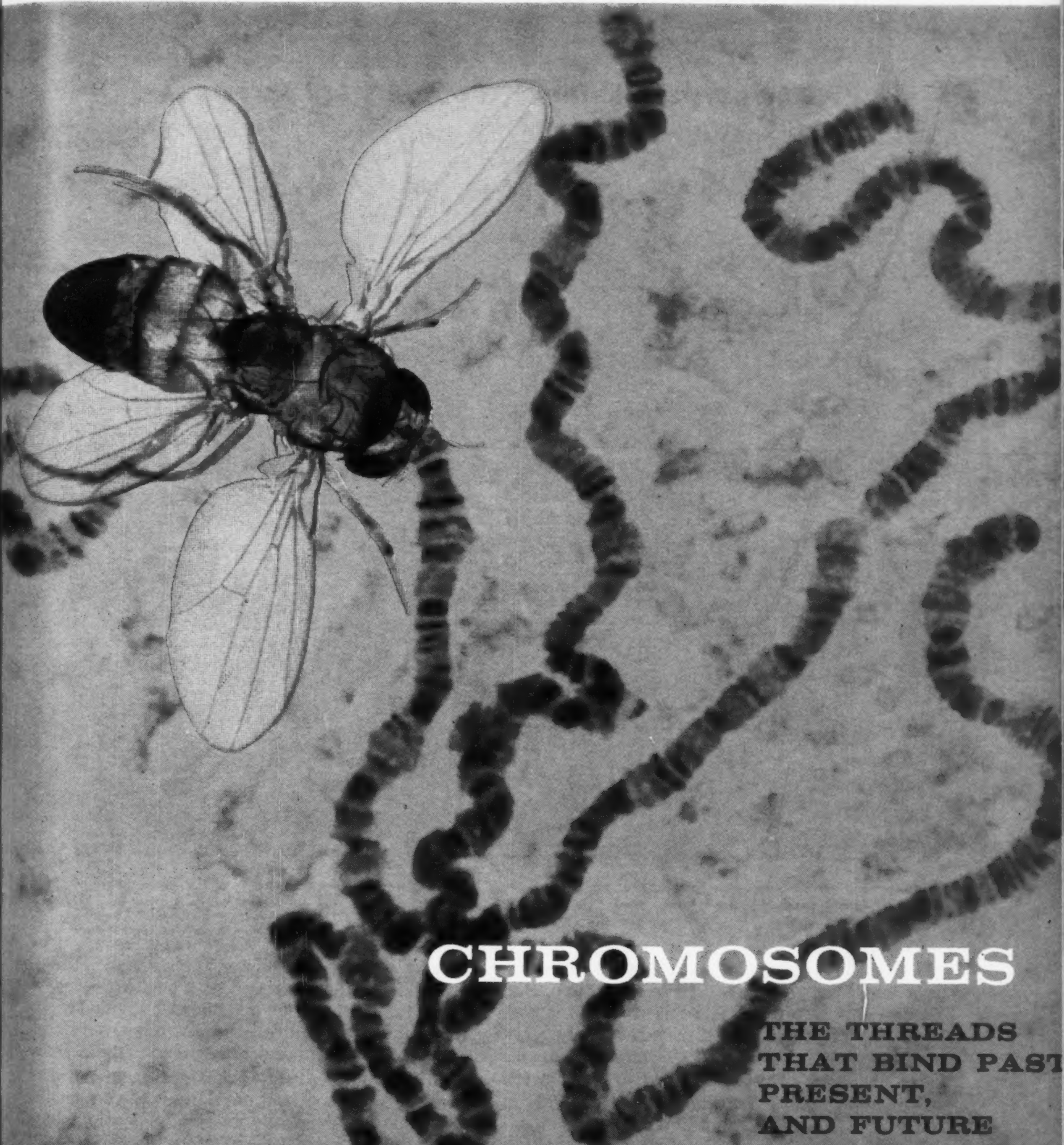

CHROMOSOMES

THE THREADS THAT BIND PAST PRESENT, AND FUTURE

See page 9

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C O N T E N T S

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Cover from Dr. B. P. Kaufmann, Carnegie Institution of Washington, and California Institute of Technology

Science in Quotes

All this new growth in science has its roots in the past. If we see farther than our predecessors it is because we stand on their shoulders—and it is not surprising if they receive a few kicks as we scramble up. A new generation is climbing on to the shoulders of the generation to which I belong; and so it will go on. Each phase of the scientific advance has contributed something that is preserved in the succeeding generation. That, indeed, is our ground for hope that the coming generation will find something worth preserving—something that is not wholly illusory—in the scientific thought of the Universe as it stands today. When we see these new developments in perspective they appear as the natural unfolding of a flower.

—SIR ARTHUR EDDINGTON

U.S. MAIL

Letters

Twins

Dear Editor:

After reading the article on "Embryology" in the February 3 issue of *Science World*, I wondered how the developing embryo of a twin differs from that of a single embryo.

Harvey Stern
New York, New York

Answer: Twin human babies are one of two types—*fraternal* or two-egg twins, or *identical* or one egg twins.

Fraternal twins, who may be of the same or opposite sex, result when two eggs are fertilized at the same time. Since each of these babies results from a different egg and sperm cell, they resemble each other no more closely than do other two children born to the same parents at different times.

About one fourth of the human twins born are identical twins. Identical twins develop from a single fertilized egg. The egg divides repeatedly and forms a sphere in which two cell masses are formed that continue their development to form two identical babies.

Fraternal and identical twins are of great interest to scientists studying the complex relationship between heredity and environment. They seek to find out, for example, whether identical twins—who have the same heredity—may be different in personality and behavior when the twins grow up in different environments.

Elements and Mixtures

Dear Editor:

I am confused. I should like to know the difference between air and oxygen. I would also like to know at what temperature air and oxygen become liquids and solids.

David Lane
West Englewood, New Jersey

Answer: Air is a mixture of gases. A little over 50 years ago the total composition of air was determined. It was found to be made up of 78 per cent nitrogen, 21 per cent oxygen, 0.94 per cent argon, 0.04 per cent carbon dioxide, 0.001 per cent hydrogen, and 0.002 per cent of inert gases plus varying amounts of water vapor. In a mixture the various compounds and elements are not combined chemically.

The gases nitrogen, oxygen, argon, and hydrogen are classified as elements. An element is one of the basic substances of the universe. It cannot be broken down into simpler substances by ordinary chemical means.

Carbon dioxide is a compound. It can be broken down by ordinary chemical processes into carbon and oxygen.

Air can be liquefied by first cooling it and then subjecting it to increased pressure. At −218.4 degrees C., the freezing point of oxygen (nitrogen freezes at −209.8 degrees C.), the gas will become a solid. Since air is a mixture, each of its components will solidify at different temperatures.

"The Cold World of Cryogenics," in the Nov. 4, 1959, issue of *Science World*, will give you many interesting facts about the liquefaction of gases.

Age of Lichens

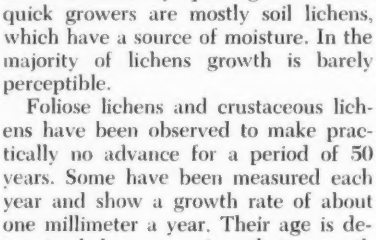
Dear Editor:

How is the age of lichens determined?

Janet Terry
Bolsa Grande High School
Garden Grove, California

Answer: Lichens are part fungus and part green or blue-green algae. Most of them grow very slowly, although a few are relatively quick growers. The quick growers are mostly soil lichens, which have a source of moisture. In the majority of lichens growth is barely perceptible.

Foliose lichens and crustaceous lichens have been observed to make practically no advance for a period of 50 years. Some have been measured each year and show a growth rate of about one millimeter a year. Their age is determined by measuring their growth rate. No *accurate* measurements have been made.



Natural History

Lichen is composite organism consisting of fungi *(top)* co-living with algae *(bottom)*. Fungi cannot make their own food, obtain it from algae, which carry on the vital work of photosynthesis.

Energy to Matter

Dear Editor:

In the "Letters" page of the Feb. 3, 1960, issue of *Science World* you state that "scientists have not yet been able to turn energy back into mass . . ." However, my physics textbook says that energy has been transformed into mass in atomic particle accelerators [see "Atom Smashers," *Science World*, Nov. 18, 1959, p. 11]. When particles are accelerated to velocities near that of light, their mass increases, according to Einstein's theory of relativity.

In 1952 the Brookhaven National Laboratory accelerated protons to 95 per cent of the speed of light, and the mass of the protons tripled. In the same year the California Institute of Technology accelerated electrons to .99999999 of the speed of light, and the mass increase was 900 times the original mass.

Did you overlook these effects when answering Peter Andreyuk's question?

Arthur J. Greenberg
Memphis, Tenn.

Dear Editor:

In your answer to the letter on matter and energy in the Feb. 3, 1960, issue of *Science World*, you fail to mention that some experiments have shown that energy can be converted into matter. As long as 25 years ago nuclear scientists discovered that a high energy gamma ray or a cosmic ray could create a short-lived positron-electron pair of particles.

W. K. MacNab
Head, Science Dept.
Sir Francis Drake High School
San Anselmo, California

Answer: Readers Greenberg and MacNab are both correct, of course. When particles are accelerated to velocities near the speed of light, part of their kinetic energy is transformed into an increase in the mass of the particles. This phenomenon was pointed out in the article on "Atom Smashers" in the Nov. 18, 1959, issue of *Science World*. Also, the interaction of a gamma ray with matter can produce positron-electron pairs of particles. The existence of such pairs has been calculated from experimental data.

The answer to the original question referred only to the creation of matter from energy on a practical scale.

The currents of the deep are still a mystery, but we know that wind, the radiant energy of the sun, and the ceaseless eastward turning of the earth combine to keep seas in constant motion

THE RESTLESS OCEAN

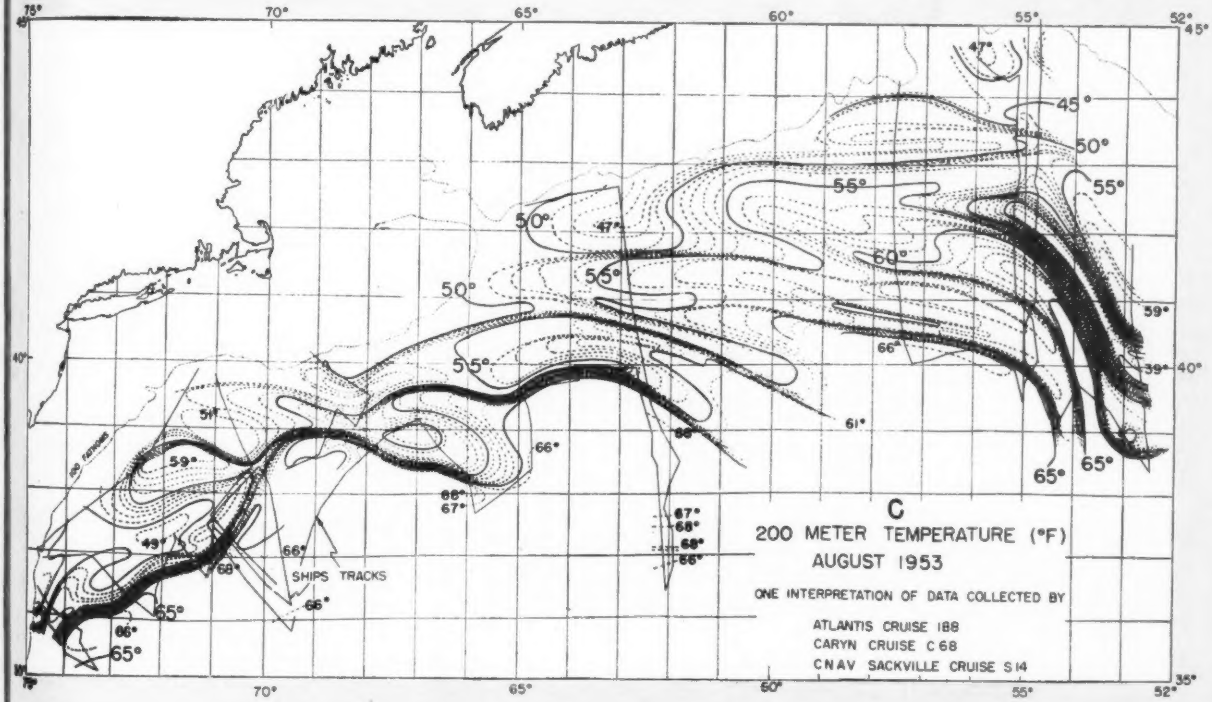


Chart from Woods Hole Oceanographic Institution

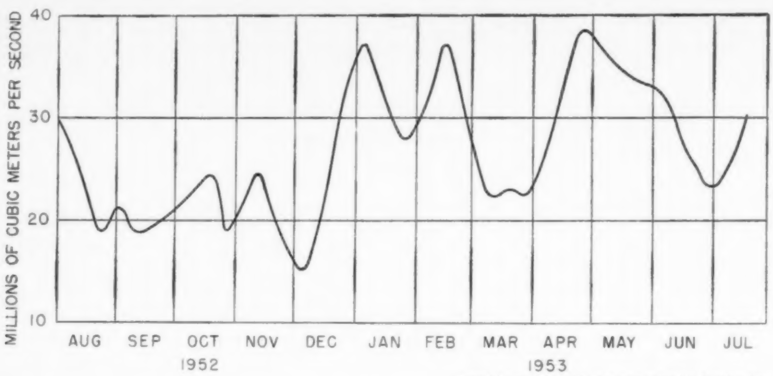
Oceanographic researchers picture Gulf Stream as a complex system of currents overlapping like shingles on a roof.

By ELIOT TOZER

IN calm weather, the soft green water off Cape Fear on North Carolina's coast seems to stretch out to the horizon, flat and endless, like a great, uneasy pool. But seamen know that the water here, far from being stagnant and lifeless, is constantly in motion.

The water moves in a current more than a mile deep and some 15 miles in width, sweeping northeastward at four to five miles per hour, transporting 60,000,000 cubic yards of water per second—almost 1,200 times the volume of the Mississippi River. It is, of course, the Gulf Stream, one of the huge currents that flow endlessly through the earth's seas, keeping the water masses in endless motion.

The northeastward course of the Gulf Stream, away from the Carolina coast, is due to the Coriolis Force (caused by the rotation of the earth). The South Atlantic currents move in much the same way—but in the opposite direction. Beneath these surface streams, a mammoth wall of water creeps northward along the western Atlantic bottom from the cold Antarctic, as far north



Graph from Woods Hole Oceanographic Institution

Graph shows record made of total volume of flow in Gulf Stream. Note how rapidly the volume can change. The reasons for these fluctuations are not yet understood.

as Florida. Between the surface currents and those of the deep, other currents twist and turn. The Atlantic, and indeed the Pacific and Indian Oceans, are almost literally moving masses of water.

When these currents clash—on coasts where there are prevailing offshore winds (generally on the western sides of oceans, off North Africa, our west coast, etc.)—they move together violently. Short, steep waves point upward and collapse, bubbling and hissing. If the intermingling currents are of different temperatures (as are the Labrador Current and the Gulf Stream), dense white fog may blanket the ocean for days.

But the ocean's movements affect our lives in a much more fundamental way. Off our Pacific coast, for example, *upwelling* occurs. Cold water rises from the depths to replace surface water driven away by prevailing offshore winds. Upwelling brings nutrients to the surface for the tiny crustaceans on which herring feed. West coast fishermen harvest a billion pounds of herring each year.

Our climate, too, is affected by the currents of the sea. Which comes first, climate or current, is a "chicken or egg" problem to scientists. The oceans and the atmosphere are linked together. The heat of the upper layers of the oceans is determined by the predominant climate of each wind zone. On the other hand, the oceans themselves influence this climate and the pattern of each wind zone. In this way, when currents bring warm equatorial water to higher latitudes, the temperature is equalized. In the same way, the chilly Humboldt current, flowing northward from the Antarctic, cools the western coast of South America.

How are these vast currents set in motion? And what powers them, that is, keeps them flowing against adverse winds and friction which tends to dissipate them?

Forces of wind, sun's heat, and earth's rotation set surface currents of the North Atlantic spinning in a great clockwise sweep in its basin.

Open Sea, by Alister Hardy (Houghton Mifflin)

Current in Clockwise Spin

If you could drop a giant spot of dye into the Atlantic, and then climb into the Project Mercury capsule and blast off to see the pattern the dye makes, you would observe that part of the North Atlantic Ocean is spinning clockwise—in a *gyre*. Water flows westward along the Equator, up the eastern coast of the U. S., and outward across the Atlantic, then along the Equator again. The "Gulf Stream system" is complex. We are beginning to understand only now that it is not just one current but a system of currents. The Gulf Stream itself, for example, is lost about halfway across to Ireland, and we do not know what happens to it. Indeed, little is known about the circulation of the oceans. There is still much to learn.

Now, if you could dye the atmosphere, you would discover that the winds follow almost the same pattern. In fact, a gigantic mound of air called the Bermuda High is generally centered right over the North Atlantic gyre. It, too, spins clockwise. The striking similarity between these spinning masses is no accident. Both wind and water are subject to the same forces: the rotation of the earth and the radiant energy of the sun.

Thus the Trade Winds are caused by the heating of the air at the Equator. Cooler air moves in from north and south to replace the rising heated air. Due to the Coriolis force, the incoming cool air moves from northeast and southwest. The northeast trades move the water westward. This is a most complicated phenomenon. No one knows how

Woods Hole Oceanographic Institution photo

Model basin has scale models of continents on inside wall. As basin rotates like earth, winds are created by vacuum cleaners. Black ink dripped into swirling water shows current patterns almost like those of ocean currents in northern hemisphere.

long the wind has to blow before the water is set in motion on this huge scale. Nor do we know exactly how wind causes water to move—whether by simple friction, the pressure of the wind against the water, or a combination of these and other forces.

Now, if there were no barriers to this flow, the water would continue westward—just as the unimpeded Antarctic Current flows eastward around the South Pole. But the westward-flowing equatorial water runs into the South American continent. It must turn, and it turns to the right. Pushed up into the Gulf of Mexico, it races out past Miami and northeastward to Cape Fear. Here, at about 40 degrees N, it is helped on its way toward Europe by the Coriolis force and constant winds, the Westerlies.

And so, it is primarily the winds—one from the east, the other from the west—that help to power the North Atlantic gyre, pushing the water along its southern path until it hits the South American continent, then along its northern path toward Europe.

But why does the westward-flowing water turn right instead of left when it bumps into the South American continent?

How Coriolis Force Works

Every object in motion in the northern hemisphere turns to the right because of the rotation of the earth. Or, more properly, in the northern hemisphere every object in motion turns to the right in relation to the earth. The reason: the earth rotates from west to east beneath the object. For example, suppose you could throw a ball from Chicago to New Orleans. Before it could get there, the earth would have rotated eastward beneath it. The ball would land to the west of New Orleans, appearing to bear right, clockwise, if you were in Chicago. The force that causes this is called the Coriolis Force. The same force helps give the North Atlantic gyre its right-turning or clockwise spin.

The Coriolis Force even affects the water level in the Gulf Stream. Along the coast of Cuba, the water level is about 18 inches higher than it is near the Mexican mainland.

"Ocean" in a Laboratory

In a fascinating experiment, Dr. William von Arx of Woods Hole Oceanographic Institution demonstrated how the winds and the Coriolis Force may help to cause the ocean's internal writhing—although the experiment was unable to show the contribution made by heat.

On the inside wall of a basin he shaped scale models of the continents of the northern hemisphere, and set the basin spinning. To this, he added just enough water to cling to the walls in a thin film, then introduced east and west winds with a couple of vacuum cleaners. Ink dripped into the swirling waters showed patterns almost exactly like those in the northern hemisphere.

The model is especially interesting because Dr. von Arx can vary both topography and winds to show possible circulations of the ocean in the past; for example, the way the Gulf Stream may have behaved when North and South America were separate continents, before they were joined many centuries ago by what is now the Isthmus of Panama.

But the winds and the rotation of the earth are not the only forces that power the ocean's currents. As we have seen, the sun is important. Water warmed by the sun's radiant energy rises just as air does.

In cold water, molecules are less active, so they can be packed together more tightly. Such water is said to be of high density; it is heavy and it sinks. Water that has been cooled in the Antarctic sinks and creeps northward along the bottom—in the same way that cold air from the North Pole flows under warmer air in what weathermen call a cold front.

The salt content also makes water more dense. In fact, if by rapid

Woods Hole Oceanographic Institution photo

Oceanographer is not "walking plank" but setting one of a series of Nansen bottles, which are used to sample temperature and salinity from ocean bottom to the surface.

evaporation the water becomes extremely saline, density currents form—even in warm water. Best known of these is the strong two-way current through the Straits of Gibraltar into the Mediterranean.

"Tools" for Probing Sea

In the Mediterranean basin, rainfall is sparse and temperatures are high, so surface water evaporates rapidly. As it becomes saltier and denser, it sinks and forms a layer several hundred feet down, then flows outward over the sill at the straits and downward into the deep sea to the level at which it is as dense as the surrounding water—about 3,000 feet—then spreads horizontally across the Atlantic as far as the Azores.

Other water must flow in to replace it. And so, along the surface, a counterbalancing inward flow begins, bringing "fresh" Atlantic water to feed the "evaporator." During World War II, German submarines used this two-way current to enter and leave the Mediterranean with engines silenced—riding in with the top Atlantic water, drifting out over the sill with the heavy bottom water.

All these ocean currents—the surface ones around the gyres in each hemisphere, the bottom currents, the intermediate currents, the coastal currents, as well as the upwellings and sinkings—are what is called the ocean's circulation.

How do oceanographers measure the temperature, salinity, and flow of ocean water? Like oceanographers of old, they do their work in the glare of the tropic sun and in the teeth of Arctic blasts. But today they use research ships, floating laboratories that take them to all the oceans of the world.

They measure temperature, down to 900 feet, with a bathythermograph. This contains a temperature-sensitive element which continuously records temperature on a smoked slide inside the instrument. Subsurface currents are measured with a Swallow buoy that determines the motion of ocean water by sending out sound "pings" that can be followed from a ship. The ocean bottom is photographed by deep-sea cameras with flash attachments that are triggered when the camera touches bottom. Hydrophones that time sound echoes are used to measure the distance from ocean surface to floor.

Samples of water and their temperature are measured with Nansen bottles. These are metal cylinders that are attached in series to a line and lowered into the sea. The bottles are open as they descend. Once they are at the required depth, a weight called a "messenger" is slid down the line. This triggers a closing device on the topmost bottle, which then releases another messenger suspended beneath it, and so on. The string of bottles is then drawn up, each containing a water sample taken at a known depth.

And on board the research vessel itself are laboratories equipped to study the chemistry of sea water, of ocean sediments, and of the creatures of the sea.

Pop Bottles Track Current

But scientists still use traditional methods to probe the ocean's secrets. Not long ago, the U. S. Coast and Geodetic Survey charted the coastal surface currents between Cape Cod and Long Island by dropping 2,000 soda pop bottles into the Atlantic! Each bottle had a card enclosed in it. About 15 per cent of the cards were mailed back. Scientists were thus able to estimate where the current must have run to carry each bottle to its stopping place.

And so, the ocean is never still. Mostly driven by winds, great masses of water move in the basins. And below the surface are the deep density currents flowing equatorward through the darkness along uncharted slopes of the ocean floor.

But massive as these currents are, and as important as they are to life within the sea, they are only part of the tremendous motions set up in the seas by the sun and moon, the motions we call tides. In the next issue, we will tell the story of the tides, the thundering waves we call surf, and the incredible Tsunami, "tidal waves" that roar across the ocean's surface at 500 miles per hour.

Within the chromosomes lie the genes, which link the past with the present and future

GENETICS, GENES, AND MUTATIONS

Brookhaven National Laboratory
Somatic mutation of snapdragon results in white area on normally all red flower.

By WILLIAM MONK

IN A few weeks from now, in city ponds, roadside ditches, lakes, and swamps literally millions of frogs will lay clusters of jelly-covered eggs. If you collect a small cluster of frog eggs and take them home or to school, you may watch the development of a single cell into a highly complex organism—a tadpole. The eggs you collect may not hatch, but if they do you can be one hundred per cent certain that the result will be tadpoles. Never canaries or baby elephants.

We are so accustomed to seeing young creatures resemble their parents that we take this for granted as the way of nature.

Scientists are never satisfied with an explanation that simply attributes a phenomenon to nature and lets it go at that. They want to know how these phenomena occur, and to what degree they are predictable and controllable.

How does a frog egg inevitably develop into a tadpole?

Life tends to copy itself, we say. In a litter of puppies, or for that matter in children of the same family, there will tend to be family resemblances. Chances are that neither pups nor children will be identical, nor will they be exact copies of their parents. They may show a blend of parental characteristics.

Indeed, mankind for a long time has known how to manage and, to some extent, reshuffle the traits of domesticated plants and animals. Breeders who took special fancy to one or another variety of dog, for example, could intensify the desired traits by selective breeding. One needs only to compare the English bull dog with the Pekinese to realize this.

Life tends to copy itself, we say—but not exactly.

The copying process is complex and involves both heredity and environment. Every living creature starts with a basic pattern it inherits from its parents. This inherited pattern is established when the chromosomes of the parents, contained in sperm and egg, unite during fertilization. Within limits set by the pattern, the environment may also help to determine the organism's individuality.

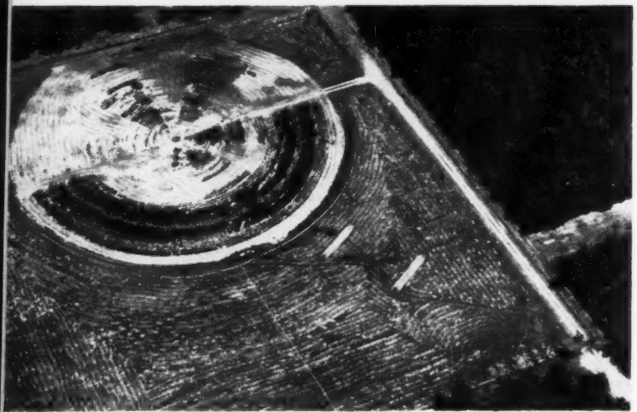
Scientists today know that many factors determine our inheritance, but the most important seem to be located on or in the chromosomes in the nucleus of the cell. They are the genes.

Gene—Protein Molecule

What is a gene? No one is quite sure. The evidence available today suggests that it is a protein molecule, or complex of protein molecules, having the remarkable capacity to organize other substances into protein molecules like itself. Although we are oversimplifying somewhat, we might think of the gene as a

Brookhaven National Laboratory
Somatic mutations—red carnations—can be reproduced from cuttings, not seed.

Brookhaven National Laboratory
Twenty hours a day of gamma radiation produces white mutation on red dahlia.



Brookhaven National Laboratory photos

Gamma source is in center of radiation field at Brookhaven National Lab. Here research is done on mutations in plants.

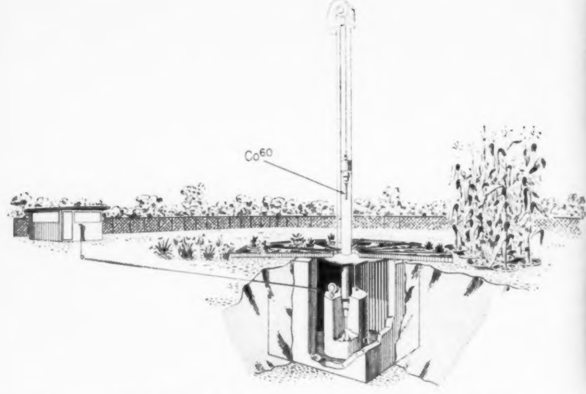
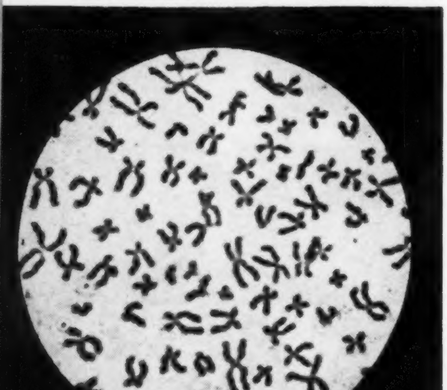


Diagram of installation in center of radiation field shows how cobalt-60 source of radiation is controlled by a cable.

National Foundation photos

Scientist adjusts microscope and camera to photo chromosomes of human cells.

Photomicrograph of human liver cell shows chromosomes arranged in pairs.



chemical compound capable of reproduction.

Genes are difficult to study, not only because they are small—about five millionths (5×10^{-7}) of an inch long—but because they are located in a matrix or case that binds them together in long chains. The genes, together with the matrix, make up the chromosomes (*see cover*). This threadlike nuclear structure gets its name from the Greek word for color, *chroma,* because it absorbs certain dyes readily when a cell is stained.

Our understanding of genes and their function in heredity began in the 1860's with Gregor Mendel, an Austrian monk who had two characteristics helpful in scientific work. He was both curious and exact. He kept voluminous and careful statistical records. These made it apparent that his results were due to some constantly operating factors and not to chance alone.

Raising several types of garden peas over a period of ten years, Mendel laid the foundations of the modern science of genetics.

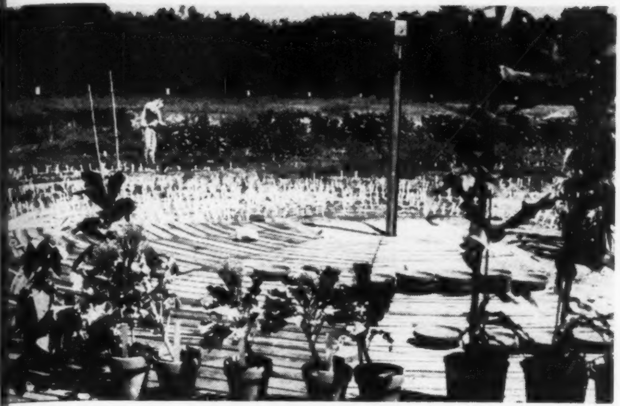
Mendel observed that specific traits were inherited from generation to generation in pea plants. Among the traits he observed were the length of the stem, the color of the seed coats, the color of the seed pods, the color of the "food" in the seeds, and the position of the flowers on the stem. In each generation, he counted and obtained the *exact* number of each kind of plant, pod, or seed. On the basis of his observation he was able to set down the "laws" of inheritance. He was able to explain, for example, how a trait can skip a generation, a child resembling, not its parent, but its *grand*parent.

Mendel theorized that something—he called them "factors"—in the egg cells and pollen grains was transmitted from parent to offspring. But exactly what were these so-called "factors" (today we call them *genes*)? Where in the reproductive cells were they located? These were questions which called for research that would combine breeding with cell study.

Mendel's work was largely unnoticed during his lifetime. It was "rediscovered" around 1900, and its importance was recognized by scientists who were beginning to combine breeding with cell research in the study of heredity.

Bits of Information

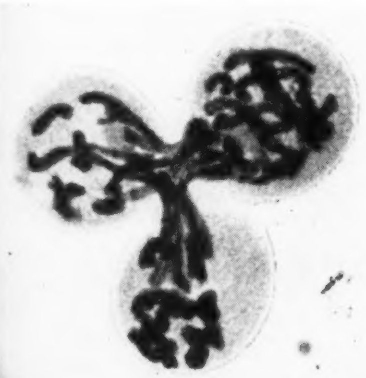
In the previous issue of *Science World,* in the article on cell differentiation we spoke of the cells as if they had a built-in information system—a "blueprint" that guided differentiation. Obviously, there is no paper blueprint inside the cell. This is simply a convenient way of explaining a difficult concept. However, if we stretch the analogy a little, we can think of the chromosome as a kind of "computer tape" bearing "programs." The genes would thus be analogous to the bits of information on the tape, guiding the development and directing the vital activities of all living things.



Plants are grown in concentric rings. Careful records are kept showing distance from radiation and time exposed.

Number shown under each plant is dosage in roentgens per day. Average plant from each dosage shows the effect.

The first clue to the location of the genes came in 1902 from the work of an American biologist, Sutton. Combining his knowledge of chromosomes in reproduction with Mendel's work on breeding, Sutton saw that if he assumed Mendel's "factors" were on the chromosomes, he could offer a theory explaining their behavior: Someplace on one of the chromosomes of the egg cell, he reasoned, is the factor determining the tall characteristic. On a similar chromosome in a pollen cell is the factor determining the short characteristic. Egg and pollen unite and the resulting plant is tall But in the next generation, since these "factors" retain their identity, when the chromosomes divide, tall and short factors can be passed on independently.



Brookhaven National Laboratory

Mangled chromosomes show abnormality as result of radiation. This cell divided into three groups instead of normal two.

To carry on this line of research, a simple organism, easy to raise in the laboratory, was needed. A tiny fly you may have seen buzzing around the grapes and bananas in fruit markets was the ideal creature. Drosophila melanogaster—the fruit fly—was exactly the right type. Easy to breed, producing several generations a year, Drosophila was later found to have one other feature making it especially adaptable to genetic studies: The chromosomes in the salivary glands of the larva are large and readily visible under the microscope.

Fruit flies are also useful for another reason: Their genes undergo mutations—changes that may be passed from one generation to the next—much more often than the genes of most other species. For example, the gene that produces normal red eye color will sometimes change and produce a white eye instead.

Mutations of this kind are useful to geneticists. The new and different characteristic can be seen and followed through many generations without too great a loss of time.

In one of the great pioneering genetic studies, Thomas Hunt Morgan and his students at Columbia University determined the rate of mutation among a natural population of fruit flies. They found 500 naturally occurring or spontaneous mutations in 15,100,000 flies.

This proportion of mutations is considered large in nature. But they do not occur frequently enough to please geneticists, nor can the mutations be predicted.

Dr. Herman Muller, one of Dr. Morgan's students, made a discovery that pushed genetics forward in a giant stride. He found that when fruit flies were exposed to X rays their genes underwent mutation.

X Rays and Mutation

The fact that some genes mutate when hit by X-ray particles suggested to scientists an ingenious method for estimating the size of genes. Suppose you were at a rifle range shooting at a steel target in the dark. If you could get one hit, indicated by the ping of the bullet on the steel, the size of the target could be measured by shifting your aim an inch at a time—right and left, up and down—until you no longer could hear the pings. With a little arithmetic, you could calculate the size of the invisible target.

Think of particles of an X-ray beam as bullets. Then by controlling the density of the particles we can use the rifle-range technique to measure the size of genes. Although nothing as convenient as a metallic ping occurs, there is something nearly as good. When a fruit fly is X-rayed and a gene is hit, its structure is changed. The change in structure gives rise to a new characteristic when the fly is bred.

(Continued on page 27)

By MICHAEL DADIN

MACHINES THAT LISTEN

Machines can compose music and recognize numbers and sounds, but we have not succeeded in designing a machine to understand spoken words

ROBBIE the Robot of science fiction is almost human—he chops wood, prepares dinner, and closes the window when it rains. Robbie's human master has only to give him his orders. In fact, Robbie's master talks to him just as he would talk to human beings. Robbie understands and does what he is told.

Unfortunately, Robbie the Robot will remain a science fiction fantasy for some time to come. The problem in making a robot like Robbie is not a mechanical one—machines have already been made that can shut windows, chop wood, and cook dinner. But the problem of having Robbie understand commands spoken in the human voice is one which may not be solved for many years.

Many scientists are working to design a machine that will understand the spoken word, but none has yet been completely successful. The reason for their difficulties lies in the miracle of language. Language is one of the most impressive characteristics of the human race. Of all the animal species living on the earth, only man has the ability to speak and understand words, and use language to communicate with his fellow man.

This fact was strikingly demonstrated by Viki, a baby chimpanzee that was raised in the household of Dr. Keith J. Hayes, a California psychologist, and his wife. Viki was given all the care and affection that a human infant would normally receive. Mrs. Hayes fed Viki, put her to bed, and changed her diapers. As she grew up, Viki's mental development was compared to that of a human infant of the same age. Viki matched the human infant in skill and intelligence, and even surpassed it in some respects. But at the age of two and a half a big difference appeared: The human infant began babbling. It learned to talk and to understand speech. Viki, however, made hardly any sounds, and never learned to speak or understand more than three or four words.

"Pictures" of Sound

Viki's brain apparently was incapable of understanding the complexities of language. Although a chimpanzee has ears and vocal chords almost identical to man's, its brain is only one third the size of a human brain. Even so, Viki's brain is thousands of times more complex than our largest electronic computers. If Viki's brain was too simple to understand language, how can we expect to make a machine which can hear and understand the spoken word?

To solve this problem, scientists have to know more about the nature of speech. To study speech in detail, they use a sound spectrograph—a machine which analyzes speech sounds and prints a picture of them on a roll of paper.

The sound spectrograph performs the same function as a light spectrograph. It splits sound into a sound spectrum, just as a prism splits white light into its many colors. Human speech and most sounds found in nature are exceedingly complex—they contain many combinations of pure tones. A pure tone is like a single note on a piano. Its pitch is regular and it is caused by a single vibrating string. The vibrations are measured as the number of cycles per second—what is called the frequency, or pitch. Note A above middle C on the piano, for example, is a pure tone produced by a vibration of 440 cycles per second.

All sounds, including human speech, are a combination of such pure tones. A large organ, which can create many combinations of pure tones, can actually imitate the sound of the human voice, trumpets, or other musical instruments.

The sound spectrograph takes complex tones such as the human voice

Bird call spectrograms can be read like sheet music. Upper mark is highest pitch, lower is lowest pitch.

Bell Telephone L

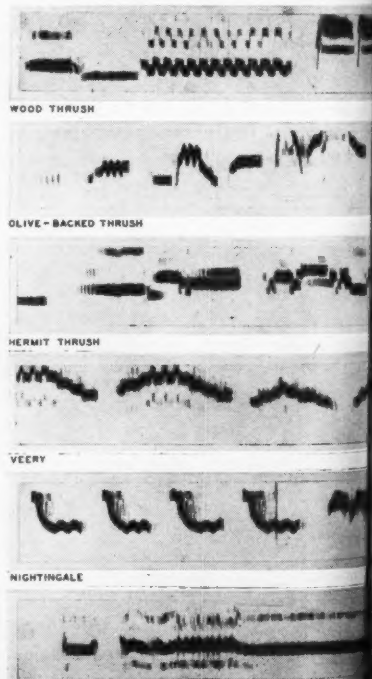


Photo from "The Alphabet Conspiracy" (Bell Labs)

No lengthy phone conversations for Viki, six-year-old chimpanzee. Although reared from infancy like a human child, Viki has been able to learn only seven words.

and breaks them down into the pure tones which make them up. It measures the tones that are present, and how strong they are, and prints a graph showing this information.

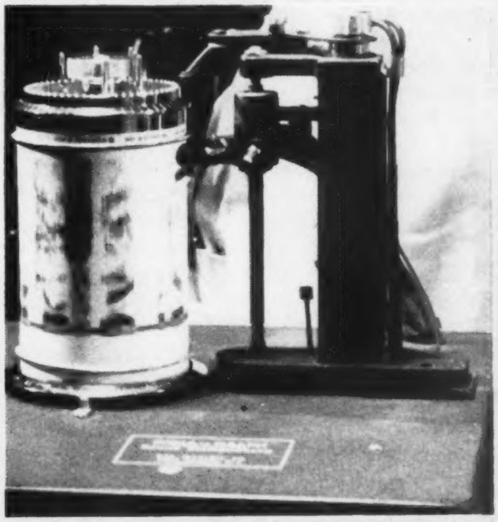
This is how the sound spectrograph works: The sound to be analyzed is first recorded on a loop of magnetic film, which is on a rotating disc. A magnetic pick-up (such as that used on a tape recorder) then "listens" to the sound. But the pick-up "listens" only to one pure tone at a time. Every time the disc rotates, the pick-up hears whether a particular tone is present. If it is, the machine makes a mark on a piece of paper. If the tone is very loud, the mark is very dark. The marks for each tone are made under each other, and the result is a graph of the recorded sound on the magnetic tape. It takes five minutes to make a spectrogram of a sample of sound 2.4 seconds long.

The sound spectrograph has helped Bell Telephone engineers to construct "Audrey," a machine which dials your phone when you speak the number you want. "Audrey," whose name stands for Automatic Digit Recognizer, can "hear" ten numbers as well as 16 of the 40 basic sounds in the English language.

Matching Tone and Circuit

To design Audrey, engineers first had to analyze the ten digits on the sound spectrograph. Each digit gave a different pattern of pure tones and a different pattern of loudness. The tone and loudness patterns of each digit were then memorized and stored in Audrey's computer memory. When Audrey hears a number spoken into the mouthpiece of its telephone, it immediately uses its electronic circuits to break down the spoken digit into its various pure tones. It then compares this pattern of pure tones with the patterns stored in its memory.

***Left*—Picture of speech is drawn by sound spectrograph. Machine records sample of speech, and analyzes pitch and strength of the different tones that make it up.**



Bell Telephone Labs photos

***Above*—Sound picture is drawn on special rotating paper strip by electric pen. Each black mark indicates a certain tone. Darker the mark, the louder the tone.**

The computer calculates which is the best "match," and within about a fifth of a second the machine lights a bulb that indicates which digit has been spoken. If the spoken word is not clear, Audrey's computer always picks the most probable choice, unless the incoming sound has no resemblance to any of the tone patterns stored in its memory. In that case, it simply gives no answer.

The digits stored in Audrey's memory are those pronounced by K. H. Davis and H. Balashek, its designers. Audrey makes few mistakes when Balashek speaks to her, but responds incorrectly about 10 to 30 per cent of the time when other males speak to her. Audrey's construction does not permit her to understand correctly the voices of females or children.

Audrey will probably never recognize human speech as well as another human being would. There are only 40 distinct sounds in the English language, called phonemes, but the pitch, quality, inflection, and emphasis of each phoneme vary greatly from speaker to speaker. A woman with a southern accent and a New England man may voice the same phonemes, but the pattern of tones in each phoneme will be very different.

RCA photo

All sounds of symphony orchestra can be generated by Electronic Music Synthesizer, developed by RCA. Operator at keyboard punches a paper tape, controlling tones.

Columbia University photo

Electronic music is heard by Prof. Vladimir Ussachevsky of Columbia University, designer of Electronic Music Synthesizer. He checks tone as adjustment is made.

Sound Circuits in Brain

To build a machine that could discriminate between words such as "open" and "shut," even when spoken by different people, would not be too difficult. But there are thousands of words which sound very much alike, such as "shut" and "shoot." Such words might confuse the best computer, especially when spoken in different dialects, or by children, men, and women.

Human beings also have difficulty in recognizing the difference between words which sound very much alike (that is, words whose tone structure is very similar). Scientists have recently found that the ear analyzes sounds very much as the sound spectrograph does. Deep inside the skull, in the inner ear, is a sensitive tissue called the basilar membrane. The endings of the auditory nerve, which leads to the brain, are distributed over the surface of this membrane.

When sound strikes the basilar membrane, it vibrates, stimulating the nerve endings in the membrane to send signals to the brain. But each area of the basilar membrane vibrates only in response to a particular pure tone. If the membrane is struck by a sound containing many tones, such as a spoken word, many parts of the membrane will vibrate, each sending separate signals to the brain. In this way the ear splits a complex sound into its many pure tones, just as the sound spectrograph does, and just as Audrey does.

However, even a complex computer such as the brain cannot always recognize a word from the different tones it contains. The brain often recognizes a word from the context in which it is used. For example, if the brain hears words that sound like "shut the gun," it would probably interpret them correctly as "shoot the gun." The brain would know that the phrase "shut the gun" simply doesn't make sense.

If a machine were to make this kind of judgment, it would need to have stored in its computer memory all the knowledge of language and human experience that a human brain has stored in *its* memory. A computer with such a capacity would be incredibly complex—if it could be built it might be as big as a skyscraper.

Since no two people have voices

that are exactly alike in pitch or vocal quality, it should be possible to identify a person merely by listening to his voice. Police detectives have used the sound spectrograph to identify criminals in the same way that they use fingerprints. The sound spectrograph shows in detail the characteristic pattern of an individual's voice. Every voice has its "voiceprint," just as every finger has its fingerprint.

In one case the police used "voiceprinting" to help identify a kidnaper. When the kidnaper anonymously telephoned for a ransom, the telephone conversation was recorded on tape, and the caller's voice was analyzed on the sound spectrograph. When the suspect was later caught, a sample of his voice was analyzed on the sound spectrograph and found to match the voice of the anonymous caller.

An experienced phonetician (speech specialist) can read a person's sound spectrogram and discover his age, sex, where he lives, and many other personal facts. Some day voiceprinting may be as common as fingerprinting.

Machines That "Talk"

If scientists can make a machine which "listens," can they also make a machine which "talks"? Many types of "talking" machines have been made in the past ten years, including machines which can simulate the sound of an entire symphony orchestra. One of the earliest of such machines was the Vocoder, built at the Bell Telephone Laboratories by its inventor, H. W. Dudley. Dudley knew that every sound in the English language can be represented by one of 40 phonemes. These 40 phonemes make up a "voice alphabet" for spoken words, just as the twenty-six letters make up an alphabet for the written word. Dudley devised an electrical signalling code for each phoneme, just as Morse code signals stand for the letters of the alphabet.

When someone speaks into the Vocoder, his voice is analyzed into its different phonemes, and a code signal for each phoneme is sent over the wires to the receiving station. At the receiving station, each signal stimulates an electronic sound generator to make the sound of the proper phoneme, thus reproducing the original speech. The reproduced speech is entirely artificial, however, and lacks the inflections and other characteristics of the original speaker's voice. The telephone company hoped to use the Vocoder to transmit more messages through its telephone lines.

Oddly enough, it is easier to make a "singing machine" than a "talking machine." The reason? All music is a combination of twelve basic pure tones, while the pure tones in speech vary greatly. A machine that can simulate musical sounds has been built recently by the Radio Corporation of America. Called the Electronic Music Synthesizer, one of the machines is located at the RCA laboratories at Princeton, N. J., and the other at Columbia University.

The Electronic Music Synthesizer can simulate the sounds of any instrument in a symphony orchestra, as well as the singing voice. The twelve basic pure tones are generated by twelve tuning forks that are made to vibrate by electromagnets. The twelve tuning forks simulate all the notes in one octave, between 740 vibrations per second and 1,397 vibrations per second. In an orchestra, all the instruments are tuned to these twelve notes, or to multiples of them. All the sounds made by an orchestra are variations and combinations of these twelve notes.

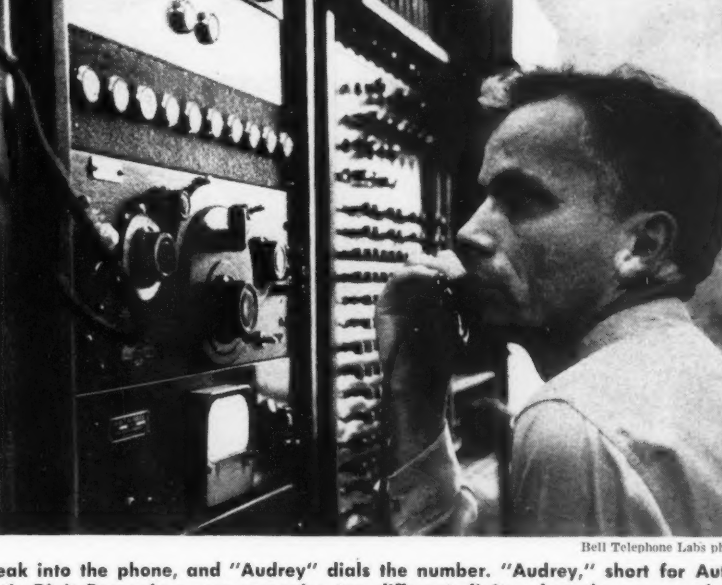
The Synthesizer can make variations in pitch by choosing one of the twelve notes and then multiplying or dividing its pitch to obtain the right octave. Other electronic circuits control duration, loudness, growth and decay of notes, frequency glide (portamento), low frequency modulation (vibrato), and timbre. The timbre of a note is determined by the number and strength of its overtones—that is what gives each musical instrument its individual quality.

Electronic Symphonies

All these variations and combinations of tones are made by electronic circuits which vary the twelve basic pure tones generated by the tuning forks. This is possible because electrical currents can be made to simulate the pattern of a sound wave.

The Synthesizer is operated by a coded punched paper roll, which is punched by an operator, or synthesist. A synthesist sits at a keyboard resembling that of a typewriter. The keys punch into the paper the choice of tones and their variations. The punched paper activates the appropriate electronic circuits, and the resulting electrical "sounds" are recorded on magnetic tape or disc. The various recordings of indi-

(Continued on page 29)



Bell Telephone Labs photo

Speak into the phone, and "Audrey" dials the number. "Audrey," short for Automatic Digit Recognizer, can recognize ten different digits when they are spoken.

Science in the news

Oral Polio Vaccine

A single swallow of live-virus polio vaccine may take the place of the Salk vaccine, which has to be given in three injections.

In Dade County, Florida, which includes the city of Miami, 75,000 people under 40 have already taken their one gulp of polio vaccine, served in ordinary paper cups. Eventually it is expected that more than 500,000 people in the county will swallow the oral vaccine.

The vaccine is practically tasteless and colorless, although a little red cherry flavor was added to convince people that they weren't drinking ordinary water. This immunization procedure is much simpler than the needle sterilization and alcohol swabbing required by the Salk vaccine injections. Also, it is free of pain, and the slight risk of infection from needle jabs.

Although vaccines containing live but attenuated (weakened) viruses have been tested overseas, this is the first test permitted in the United States by the U. S. Public Health Service. The Public Health Service believes that a weakened modified virus might possibly revert to a disease-causing type after multiplying in the subject's intestines. In the Salk vaccine, only dead polio virus is used.

Dr. Herald R. Cox, who helped to develop the live-virus vaccine, says that the vaccine will not cause disease after it is swallowed. He insists that the chance of developing polio from his vaccine is one in a billion.

Dr. Cox is a leading American virologist. Working on Rocky Mountain spotted fever in 1938, he caught the disease. He believes he would have died if he had not previously taken a vaccine he had developed against the fever.

Mapping of Moon

Two famous European research centers, the University of Manchester, England, and the French observatory, 9,500 feet high on the Pic du Midi in the French Pyrenees, are to play a major role in a program for accurate mapping of the moon.

The moon map is being sponsored by the U. S. Air Force. Some 12,000 pictures have so far been taken of the moon, showing sunrises and sunsets in the lunar landscape. However, some 200,000 pictures are needed to make proper calculations about the height of lunar features such as mountains, peaks and hills, with a precision of about 26 feet.

Main goal of the program is to produce an accurate map of the moon on the scale one to one million.

On photographs taken with the 24-inch telescope at the Pic du Midi Observatory, objects down to a size of 1,500 feet, corresponding to one second of arc, can be distinguished.

A main problem of the program is that there is yet no proper system of reference in existence. All measurements on the moon so far are based on 200 to 300 ill-defined peaks and hills.

Research done by Pic du Midi Observatory and the University of Manchester has shown that small craters, known as craterlets, should be used as points of reference rather than hills and other mountainous objects.

Because of the non-existence of a lunar atmosphere, the moon's surface might become ionized during lunar daytime by ultraviolet solar light. This might cause a charged dust atmosphere, the negatively charged dust drifting slightly above the positively charged lunar surface. This situation might cause great trouble to any future space traveler landing on the moon.

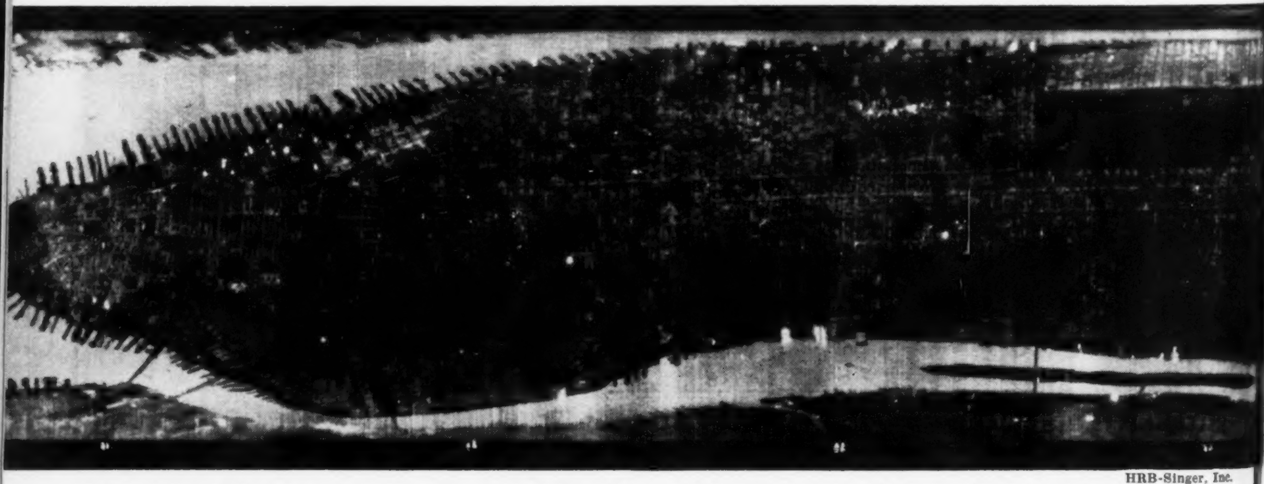
Tough Bacteria

Scientists have found that many types of bacteria can survive heat as intense as that presumed to exist in sunlight on the surface of the moon—a temperature believed to be about the boiling point of water on Earth.

Dr. Stephen Zamenhof and Dr. Sheldon B. Greer, biochemists at Columbia University's College of Physicians and Surgeons, found that many bacteria survived in a vacuum when the heat reached 275 degrees F., 63 degrees above the normal boiling point of water at sea level.

Many bacteria should be able to survive in the dry state of a vacuum on the moon's surface, the scientists believe. Thus man-made rocket ships might carry bacteria to the moon where they would thrive.

It was previously assumed by most scientists that only bacterial spores survived high temperatures. Spores are forms of bacteria that are extremely re-

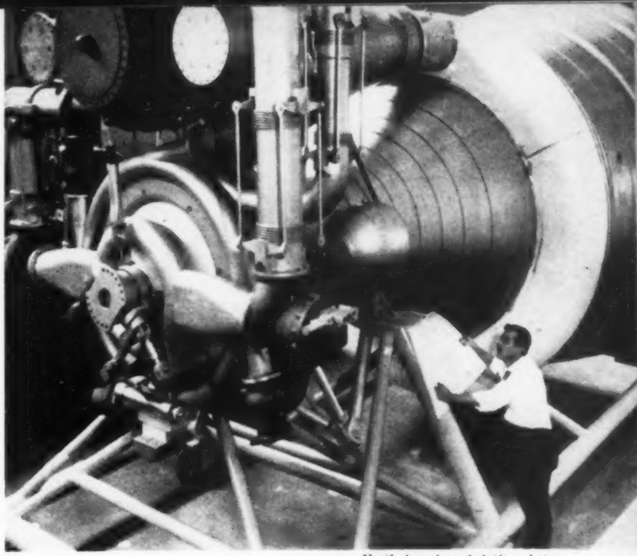


HRB-Singer, Inc.

Aerial photo of Manhattan island was snapped at night with infrared film. Film is sensitive only to heat, not light. Brightest objects in photo are hottest. Photo was taken in winter, when water around island is warmer than land.

Wide World photo

Inch-long Australian frog doesn't hop—an exception in the frog family. Frog is colored with stripes of brilliant yellow and red, is one of eight captured in Australia. Hopless frogs are now housed in Museum of Natural History, N.Y.C.



North American Aviation photo

Model of America's most powerful rocket engine, producing 1,500,000-pound thrust, to be ready in four years. Exhaust nozzle is at right, fuel pumps left. Six motors would give 9,000,000-pound thrust to send 100,000 pounds to moon.

sistant to heat, chemicals and radiation.

"But now we see that in space—a vacuum—dry bacteria can be almost as hardy as spores," Dr. Zamenhof said.

This information could mean that Earth-bacteria are now growing on the moon if the decontamination processes of the Russians failed. U. S. scientists assume, however, that the Russian rocket that crashed on the moon last September was sterile. If the Soviet missile contaminated the moon, it may spoil chances of determining whether any organisms found on the Earth's satellite originated during early stages of the development of the solar system.

Eclipse March 12

On the night of March 12-13, 1960, observers in the United States and Canada will be able to see a total eclipse of the moon. During that night the full moon will fade to a dull red as it passes through the shadow cast by the Earth.

This is the first time in three years that a lunar eclipse will be visible from North America. Over most of North America the eclipse will occur early Sunday morning, but on the Pacific Coast it will begin before midnight. The moon will be full at the time of the eclipse. A lunar eclipse can occur only at full moon, when the Earth is between the moon and the Sun.

The moon will enter the outer part of the Earth's shadow, the penumbra, soon after midnight, Eastern Standard Time (or one, two, and three hours earlier in the Central, Mountain, and Pacific time belts). At that time a lunar observer will be able to see the Earth beginning to hide the sunlight from the moon. At 2:41 a.m., EST, March 13, the moon will be completely in the Earth's shadow, and the total eclipse will begin.

The moon will remain in the shadow for 95 minutes. During that time it will remain visible, although much darker than the usual full moon. The Earth's shadow is not completely dark. The atmosphere surrounding our planet acts as a prism which bends sunlight around the Earth and into the shadow. The blue rays in the sunlight are scattered by the Earth's atmosphere, but the red rays pass through it and are bent into the Earth's shadow. This red light will give the eclipsed moon a coppery-red hue.

The southeastern edge of the lunar disc will begin to emerge from the Earth's shadow at 4:15 a.m., EST, March 13. The shadow of the Earth will be seen gradually creeping across the moon. The moon will be clear of the umbra (the inner shadow) at 5:18 a.m., EST, marking the end of the total phase. It will remain in the penumbra for more than an hour. Then the moon will shine with its full brilliance until it has set.

During a total eclipse, the surface of the moon cools off rapidly. When the moon is full, the sun has been shining on it constantly for a week, raising the surface temperature to about 212 degrees F., the boiling point of water. During the eclipse, the surface temperature drops to about 160 degrees below zero F. Unlike the Earth, the moon has no atmosphere to serve as an insulating blanket.

Glaciers Declining

Glaciers, which cover about ten per cent of the world's land area, are definitely declining, a Russian scientific report contends.

Up to the time of the IGY, glacier data were only approximate and inaccurate. It was thought, for example, that the thickness of Antarctica's ice cover was about 2,000 to 2,600 feet. However, glaciological investigations during the IGY indicated that the average thickness of the ice was close to 6,500 feet and sometimes reached 13,000 feet.

Glaciers cover almost 6,000,000 square miles of the earth and contain 11 times as much water as all the land's surface waters.

Glaciation exerts a considerable influence on the Earth's climate.

Science World graphic

Diagram shows how eclipse of the moon by the Earth will take place on March 12-13.

Science in the news

Flying Tiger Shark

Dr. Earl Herald, director of Comparative Zoology at the Steinhart Aquarium in San Francisco, needed a shark recently—and a "sharky-looking shark" at that.

To illustrate his lecture on an educational TV program in San Francisco, Dr. Herald wanted to show his viewers a really ferocious shark. But the only shark available to him was a nurse shark, which lives in California waters. And a nurse shark looks about as mean as an angry flounder.

So an SOS was sent to the Coney Island Aquarium in New York City. Dr. Herald asked for a sand-tiger shark. Such sharks are native to New York waters, and are famous for sharp teeth and snappy tempers.

Fortunately, the Coney Island Aquarium had a young tiger shark on hand. Now a new question arose: What was the best way to send four feet of live shark named Waldo some 2,571 miles from coast to coast?

Finally, Christopher W. Coates, director of the Coney Island Aquarium, hit upon a solution. He pointed out that plastic bags were being used to "package" almost everything these days—from apples to zucchini squash. So why not ship Waldo in a plastic bag filled with salt water?

And that's just what the Coney Island ichthyologists did. After they had sealed Waldo in the bag, they pumped oxygen into it. This increased the oxygen content of the water, so that Waldo wouldn't suffocate during his trip. Then the plastic bag was encased in a large box.

When the flying tiger shark reached San Francisco, Dr. Herald rushed Waldo to an aquarium, and dumped him in. Was Waldo still as mean as ever? Dr. Herald peered into the aquarium, grinned, and commented: "He looks like a barbed-wire fence swimming at you."

But the shark tale was not over yet. It seems that Waldo had made friends with a she-shark named Winnie back in Coney Island. After Waldo departed for the coast, Winnie began to pine for her high-flying boy friend. So the plastic bag was rushed back to Coney Island. Today Waldo and Winnie are sharing an aquarium in San Francisco.

Theory on Oil

The oil that heats our homes and fuels our cars may have come from gases released into the air by growing vegetation.

This is the theory of Dr. Frits W. Went, a plant physiologist working at the Missouri Botanical Garden in St. Louis.

Dr. Went analyzed air that had blown over one square kilometer of sagebrush (about four-tenths of a square mile). He found that every year the sagebrush in this area released five tons of volatile organic matter into the air. This volatile organic matter is composed of hydrocarbons, a group of compounds containing hydrogen and carbon, related to the compounds in petroleum.

These hydrocarbons may be the cause of the pungent aromas which western cowboys smell when they ride through sagebrush country. The vaporized hydrocarbons may also cause the blue haze often seen over heavily vegetated areas. Dr. Went theorizes that these gases are washed out of the air by rain and deposited in the silts and clays of lake bottoms and river mouths, where they eventually turn to oil.

Dr. Went's theory contradicts the now prevailing theory that oil was originally formed from the remains of tiny sea creatures that fall steadily to the ocean floor.

Dr. Went estimates that all the sagebrush of the western states produces a million tons of airborne hydrocarbons each year. The world's pine forests should perfume the breezes with another 50,000,000 tons a year. The grand total for all the world's vegetation may be as much as 175,000,000 tons a year. Such a level of production would easily account for the tremendous size of the earth's oil reserves.

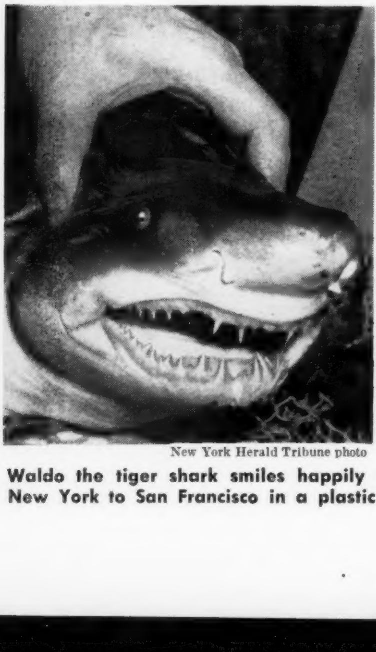
The theory does not give a complete answer to the problem of petroleum formation. It does fit well with the fact that oil and coal were formed at about the same time—when the earth was covered with dense vegetation.

Sleeping Sickness

Sleeping sickness, a scourge to human beings and livestock in many tropical areas, has struck again—this time in northern Nigeria.

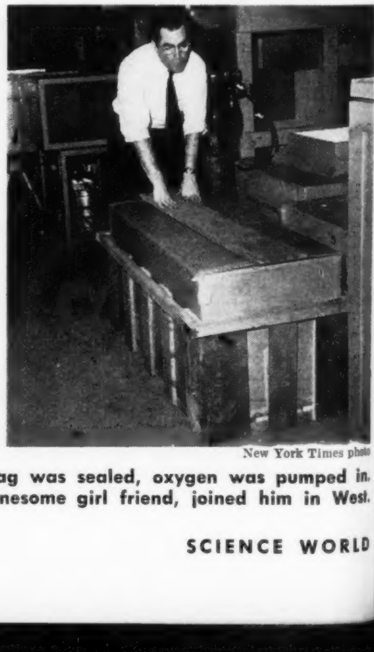
Villages have been decimated by sleeping sickness, and large areas infested by the tsetse fly, which carries the disease, have been abandoned.

To combat the scourge, the Nigerian government is slashing away vegetation in four-mile-wide swaths to keep the fly



New York Herald Tribune photo

New York Times photo



New York Times photo

Waldo the tiger shark smiles happily after traveling from New York to San Francisco in a plastic bag filled with salt water. After the bag was sealed, oxygen was pumped in. Winnie, Waldo's lonesome girl friend, joined him in West.

British Information Services photo

Tsetse fly *(above)* carries African sleeping sickness. Fly punctures skin, sucks blood with tube-like mouth part. As blood is sucked from victim, trypanosomes *(enlarged model below)* from fly's salivary glands are deposited in victim's bloodstream. When microscopic organisms multiply, sickness results.

American Museum of Natural History photo

from infesting new areas with disease.

Fortunately, the disease is easily detected. The parasitic trypanosome which causes the disease is found in the salivary glands of the victim. Mobile field teams of internes examine the necks of villagers for swollen glands. Swollen glands are punctured and the extracted material is examined for the parasite. Such mass examinations result in detection of about 5,000 cases a year.

A drug known as antrypol is used to treat patients in early or intermediate stages. Advanced cases are treated with a stronger drug, melarsen sodium.

Car Fumes Control

The automobile industry was urged to equip all new cars with devices to control gases that are polluting the air.

Secretary of Health, Education, and Welfare Arthur S. Flemming told Congress that the air pollution problem is growing every year.

Up to now, only new cars to be sold in the Los Angeles area have had exhaust control devices, available as optional equipment. The smog there has created a danger to health.

Los Angeles has more autos than any other city in the nation. The exhaust fumes react with sunlight to produce substances irritating to eyes and the mucous membranes of the nose and throat. Los Angeles is bounded on three sides by mountains. Ocean winds on the fourth side blow onto the land. Stopped by the mountains, the winds form a blanket of air over the city's fumes, preventing them from moving away.

The equipment can be installed in cars at relatively small expense. A device to burn off the unconsumed poisonous gases in the engine's exhaust would not cost more than about $10 on a new car, or $30 on an older one.

Royal Society

The Royal Society of London for Improving Natural Knowledge, the oldest scientific society in the world, celebrates its 300th birthday this year.

The Royal Society was founded in the city of London on November 28, 1660, by a group of twelve scientists and philosophers. Included among them was Robert Boyle, who discovered the relation between the volume of a gas and its pressure, known as Boyle's Law.

Two years later King Charles II granted the group a royal charter which gave the society its constitution and its name. Over the last 300 years many famous scientists have been members of the Royal Society, among them Isaac Newton, Robert Dalton, Michael Faraday, Charles Darwin, J. J. Thompson, and Ernest Rutherford. In the reign of Queen Anne, the society supervised the Royal Greenwich Observatory.

At one time amateurs with scientific interest could become members. Today, however, only professional scientists with an impressive record of achievement are invited to join. Becoming a fellow of the Royal Society is a much prized honor.

In 1900, 15 fellows (members) were elected each year. In 1958 there was a total of 655 fellows, including 61 foreign members. The Royal Society encourages the international exchange of scientific information.

Award to Dr. Ewing

Dr. Maurice Ewing of Columbia University has been awarded the Vetlesen Prize for achievement "resulting in clearer understanding of the earth, its history, or its relation to the universe."

Dr. Ewing, director of Columbia's Lamont Geological Observatory, is the first recipient of this international award. The award, which will now be given every two years, consists of a gold medal and $25,000.

With the Vetlesen award in geophysics, all areas of science now receive international recognition. Physics, chemistry, and medicine and physiology are covered by the Nobel Prize.

The International Geophysical Year of 1957-58 and the launching of Earth satellites have greatly stimulated interest in the earth sciences.

Dr. Ewing describes the earth sciences as being on the threshold of significant advances. "The study of the earth is about where the study of physics was in the 1890's," he says. Dr. Ewing's prediction indicates that we can look forward to a better understanding of our planet as a whole, its weather, its water and ice, and its interior.

UPI photo

Plants without soil may change desert sands into fertile oases. Chemist Herbert Kurth of West Germany uses gelatin-like material mixed with sand to hold water.

today's scientists

Dr. Janice Button
Atomic Explorer

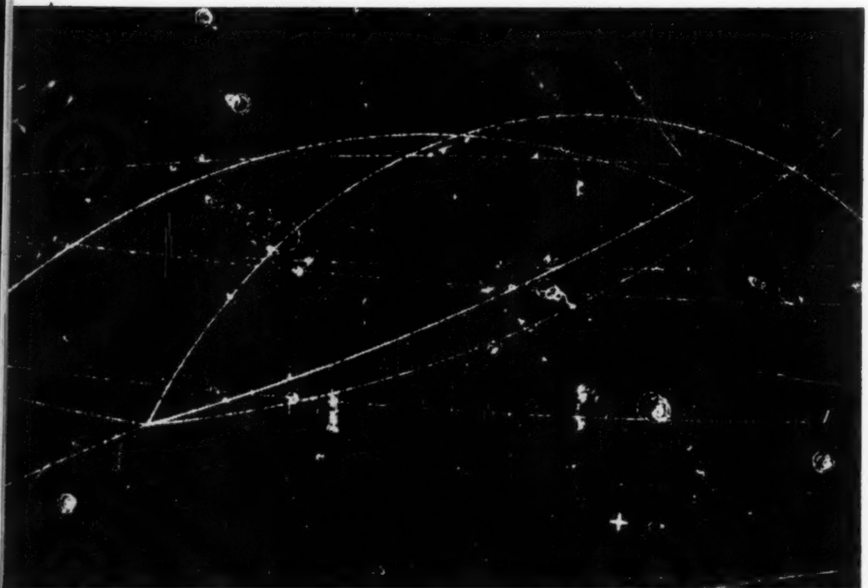
Dr. Button (*center*) with fellow "explorers" Dr. John Poirier (*left*) and Dr. Phillipe Eberhard

AT A table by a window overlooking San Francisco Bay, a group of men—and one woman—combine conversation and breakfast. Their talk is sprinkled with terms like "electron volts," "hyperons" and "strange particles." Occasionally one of them illustrates what he is saying by scribbling a few lines and Greek letters on a paper napkin.

The breakfasters are physicists at the Lawrence Radiation Laboratory of the University of California, high in the hills near Berkeley. The fresh-faced girl with blonde hair is one of the physicists. Twenty-eight-year-old Dr. Janice Button does the kind of detective work that would baffle the most skillful private eye. Most of the clues she follows are invisible. The object of her search is a particle—a minute part of the atom's nucleus—that lives only one twenty-seven-billionth of a second (2.7 x 10^{-10} seconds). It leaves no trail and can be recognized only after it is gone.

Dr. Button and her colleagues are looking for the antilambda hyperon, one of the many particles that can be isolated from the nucleus of the atom. They spend their days – and many nights—producing thousands of antiprotons. Then, carefully, they watch for and measure any interactions which *may* prove the existence of lambda and antilambda hyperons. Because scientists don't yet know why lambda and antilambda particles exist – what purpose they serve in the structure of the atom —they call them "strange particles."

The antilambda hyperon made its debut simultaneously with a brand new piece of scientific equipment. The giant 72-inch liquid hydrogen bubble chamber at Berkeley, largest bubble chamber in the world, was used for the first time in the attempt to produce and identify antilambda particles. The experiment was launched by Dr. Luis Alvarez and Dr. Lynn Stevenson, University of California physicists. Dr. Button worked as a graduate student under Drs. Owen Chamberlain and Emilio Segre, both Nobel Prize winners in physics. She joined the experiment as a full-fledged Ph.D. physicist in 1959.



Lawrence Radiation Laboratory, University of Calif.

Lambda and antilambda hyperons leave no tracks, but they split into two particles that do leave tracks. These particles form curved V, with angle as "fingerprint."

Curiosity Keeps Her Going

Dr. Button, Dr. Stevenson and Dr. Alvarez were working as a team when they obtained photographic and mathematical proof that antilambda particles had been traced—if not seen.

Why do men and women of science spend so much time and effort studying these tiny bits of stuff?

Like most scientists, Dr. Button and her fellow physicists simply want to *know*. For them, an unanswered question is reason enough to search for an answer. The fuel that keeps them going is a tremendous curiosity about the nature of things—a particular curiosity about the elementary building blocks of matter, the tiny particles inside the atom.

This curiosity always has been a part of Janice Button's mental make-up. As a little girl of seven, she started asking questions about her father's work. He was an electrical engineer in Needham, Mass., a suburb of Boston. His daughter enjoyed mathematical puzzles

(Continued on page 26)

tomorrow's scientists

PROJECT: Research in Radiation Induced Mutations

STUDENT: **WAYNE SETTLE** SCHOOL: KEYSTONE HIGH SCHOOL, KEYSTONE, INDIANA

SCIENCE ACHIEVEMENT AWARDS WINNER TEACHER: **RALPH D. SETTLE**

[If the structure of a gene is altered so that it produces a new characteristic, it is called a mutant or changed gene.

It has been known for some years that X rays will produce mutations in the genes of certain species of plants and animals. The production of mutations in the laboratory by exposure to X rays suggested the theory that some naturally occurring mutations result from radiation emitted by natural sources.

The discovery that man could produce isotopes that emit gamma radiation has given geneticists a new tool with which to work. It is now possible to expose reproductive cells to gamma radiation of known intensity. There is no way known of producing a specific mutation or of knowing how the mutations will affect the plants or animals resulting from the sperm and egg cells involved. It is a matter of "wait and see."

With a field for his laboratory and garden tools and kitchen utensils for equipment, Wayne Settle is actively engaged in scientific research of fundamental importance. He is seeking the answer to one of man's most pressing problems: "Can radiation be used to produce new and useful varieties of plants?"]

Wayne reports, "My interest in radiation and its effects on the germ tissue (reproductive cells) of plants began when I visited the Argonne National Laboratory in the fall of 1956."

WAYNE'S PROJECT

Dr. T. S. Osborne of the University of Tennessee sent me some barley seed irradiated with cobalt-60 (a radioactive isotope). Those seeds were grown as a first project with the object of noticing and recording any variation from normal occurring during the first few weeks of growth.

My records on the barley plants show that germination (sprouting) was not affected, but that growth was retarded and the stems were contorted.

After completing my first experiments and writing my report to Dr. Osborne, I asked if I could continue a series of experiments for several generations, since most mutations act as *recessives* and do not produce observable effects in the first generation. Radiation damage generally is more evident than mutations in the first generations of plants grown from irradiated seeds.

Dr. Osborne and I decided the best plant for my purposes would be German millet, a cross-pollinating plant that can be grown in all parts of the United States.

In July 1957, I received the millet seed which had been irradiated by gamma radiation from a cobalt-60 source in the following dosages: 10KR (kiloroentgen), 20KR, 30KR, 40KR, and 50KR. Along with the treated seeds, he sent 30 per cent of untreated seeds from the same parent stock as control.

In making observations on the first generation of plants, I recorded the per cent of emergence, per cent of plants maturing, and average seedling height. In the control plants I found two off-types which seemed to be twin spikes. They were due either to spontaneous mutations or environmental damage—most probably the latter.

After preparing seed bed, the seeds from a single plant were set in each row.

Wayne often had to remind himself this was research, not just plain hard work.

To prevent cross breeding of plants, each flowering head was covered with sack.

Hand-threshed seeds from each plant were stored separately with their records.

An off-type appeared in the controls. Was it due to mutation or environment?

In the seedling stage the 20KR plants showed least variation from the controls. At maturity they were taller and stronger stalked, and bore better heads than the controls.

The 10KR plants were shortest and had weak stalks, while other growth features compared favorably with the controls.

The results of two dosages, 30KR and 40KR, were nearly the same. They had strong stalks and large heads. The 50KR seeds yielded plants with short weak stalks and small heads. These plants also exhibited deficiency of chlorophyll.

In the spring of 1958 I started the second generation from seeds of the first generation.

The fact that weather conditions during both years were unusually wet, probably affected growth. The seeds from the two off-types did not germinate. Therefore I was unable to determine whether they were due to environment or mutation. The second generation of controls again produced similar off-types.

Chlorophyll seemed to be richer and more uniform as the dosages increased, while the control group had several very light colored plants.

The 20KR dosage produced the most vigorous plants, as it had in the first generation. However, this time the 40KR dosage produced plants almost as vigorous. One of the 40KR plants had a very coarse stalk—three eighths of an inch in diameter.

Two plants, one in the 10KR and the other in the 20KR, differed from the rest by being less than one foot tall, yet having stalks strong enough to support the heads. Several other plants were short, but they had very weak stalks.

The flowering and the ripening dates were almost identical for all dosages and no increased disease resistance was noted. Slight insect damage and a small amount of rust was found uniformly distributed among all plants.

The next generation will determine whether the changes noted this year were inherited or caused by weather conditions and other environmental damage. I hope to make a microscopic study of the chromosomes in the future generations.

PROJECT: A Water Channel for Aerodynamic Flow Studies

STUDENT: **HARVEY PICKER**
SCIENCE ACHIEVEMENT AWARDS WINNER
FOREST HILLS HIGH SCHOOL, NEW YORK CITY
TEACHER: **HARVEY POLLACK**

[Often, as in the case of ocean currents, the phenomena a scientist wishes to investigate are too large, too small, too fast, or too complex to be treated in the laboratory. When investigating problems of this type, the scientist sometimes is able to find some simpler device or model which, although essentially quite different, will in its behavior resemble the phenomenon he wants to investigate. He is using an *analogy*.

For example, you can't get the earth and an artificial satellite into a classroom. Yet by hanging an iron weight on a long string and setting it in motion around a magnet it is possible by the analogy between magnetic attraction and gravitational attraction to explain some of the forces at work.

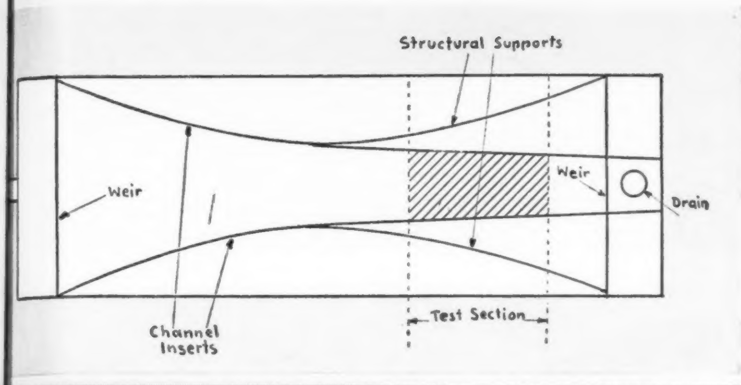
If you hold a sheet of notebook paper by two corners and blow across the upper surface, the paper will be lifted a little. You have a situation analogous to the wing on a plane in flight.]

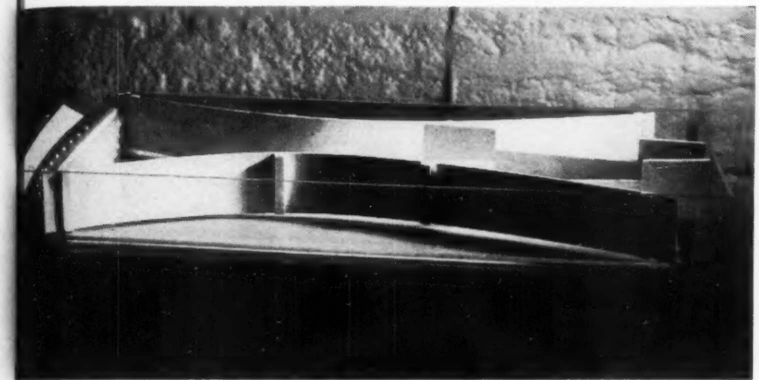
HARVEY'S PROJECT

For many years [reports Harvey Picker], I have been interested in aerodynamics. When I discovered that a mathematical analogy exists between the two-dimensional flow in a compressible gas and the surface flow in a shallow, open water channel, I thought I could use this principle to increase my knowledge by experimenting with a simulated wind tunnel.

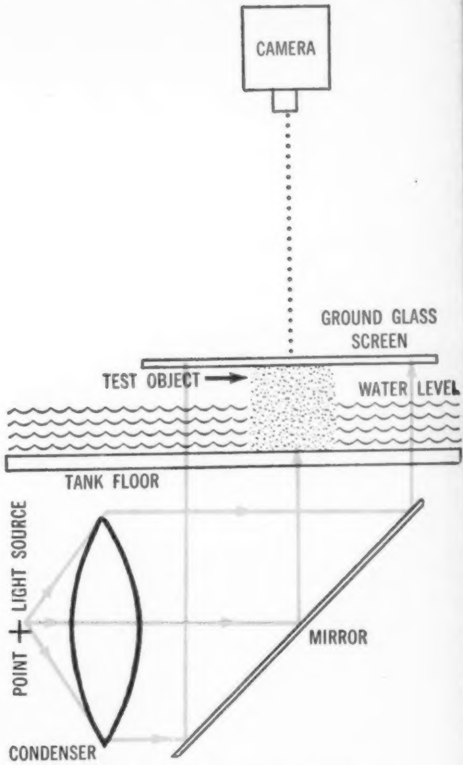
Because of the analogy, which is simply a matter of mathematical formulae—physically there are basic differences between the flow of a compressible gas (air) and an incompressible liquid (water)—it was possible to construct a simulated wind tunnel fairly easily and inexpensively.

Furthermore, since the velocity of propagation of gravity waves in water corresponds to the speed of sound in air or Mach 1, it was possible to ob-





It was not too difficult to build the tank of plexiglass. However, it required special nozzle, plexiglass honeycomb, and inserts to control flow.



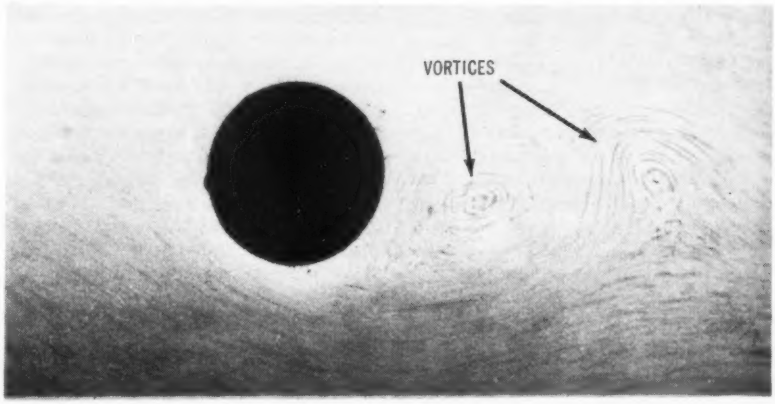
To photograph wave flow around test objects, light source was placed under tank.

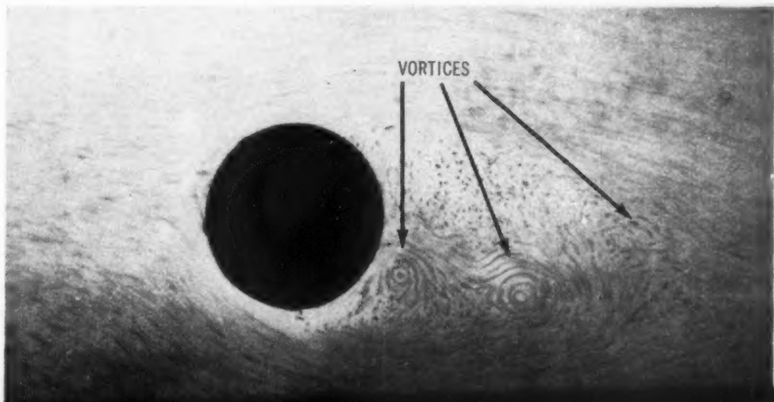
serve effects such as shock waves at stream velocities as low as 2 feet/sec.

To start, I built a basic tank of Plexiglass sheet. A circulating system consisting of a rubber hose hooked to a small centrifugal pump gave satisfactory flow.

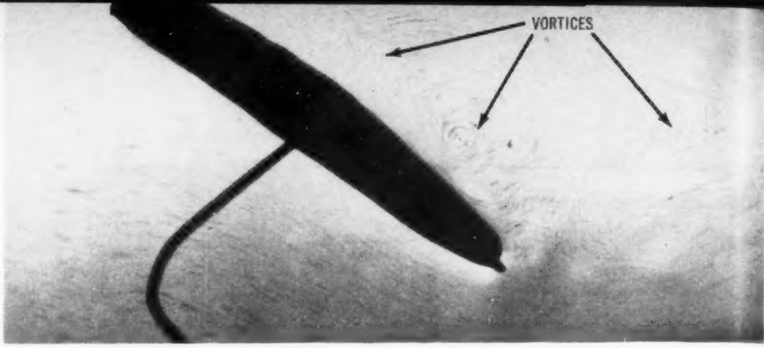
While this arrangement was not difficult to build, there were problems in achieving uniform flow. My trouble was that the inlet hose of small diameter opened suddenly into a wide channel. (In an incompressible fluid, the equation of continuity is $AV = K$, where A represents cross-sectional area and V represents velocity. If A increases, V must decrease.) Thus there was an abrupt decrease in flow velocity, resulting in partial stagnation and local backflows.

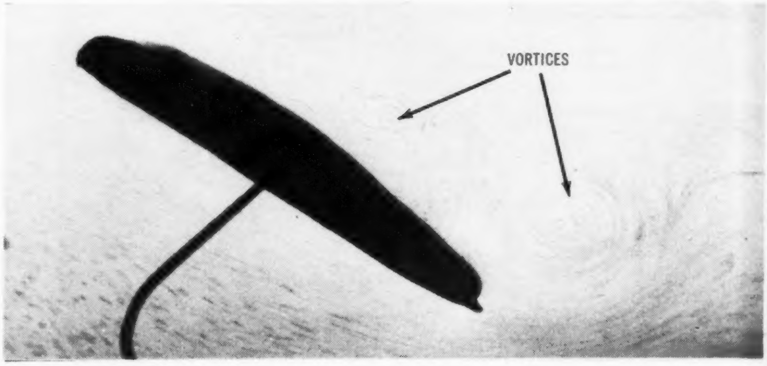
The first step in correcting these difficulties was to spread the flow across the full width of the tank. This was accomplished by incorporating an inlet nozzle consisting of two flat plates converging into a narrow slit. But this did





Photos at right show how vortices formed around test cylinder in tank at speeds below Mach 1. Flow was made visible by sprinkling aluminum particles on water.





Tests of air foils in tank at speeds below Mach 1 resulted in vortex formations similar to those formed above the wing of plane in flight or in a wind tunnel.

not eliminate backflow. The remedy to this situation was the addition of two inserts in the channel, which reduced the effective volume of water per unit time and accelerated the flow in the test section, in accordance with the equation of continuity.

Still the flow was turbulent. To control its irregularities, I made a honeycomb by gluing several 1" wide strips of corrugated Plexiglass on top of each other. This device was placed ahead of the inlet nozzle.

Simple Solution to Problem

Although the flow was now reasonably steady and uniform, there were air bubbles on the surface which created disturbances in the test section. The solution to this problem was so simple that it eluded me for a while. Two wires at surface level would burst the bubbles before they reached the test section. By these measures, I obtained a flow satisfactory for the observation of aerodynamic phenomena.

The velocity was measured and Mach equivalent determined by timing small floating particles over 1 ft. of the test section, by means of a stopwatch which could be read to the nearest 1/10th of a second.

There is a weir at either end of the tank for purposes of maintaining constant depth. I thought that there might be some stagnation close to the tank floor. However, soundings made with a makeshift Pitot-static tube in the test section showed the velocity did not vary with depth. Since there was no stagnation, I could proceed without corrections.

Studies were made using a cylinder, wedge and wing section.

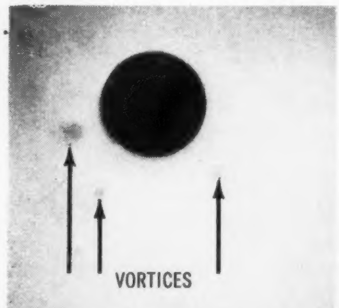
Several lighting techniques were tried in photographing the streamlines. Satisfactory results were obtained by placing a fluorescent light about 3 ft. below the tank bottom with a ground glass plate fixed to the bottom under the test section. This produced a diffusely lighted background against which aluminum powder, sprinkled on the surface to show streamlines, showed up as dark particles.

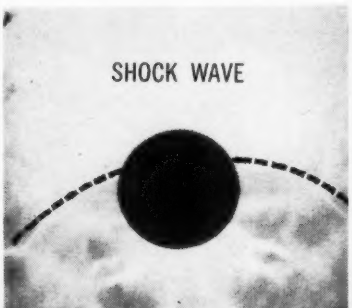
The shadowgraph technique used in making photographs in wind tunnels is based on the difference in the refractive index of air at different densities. Such differentials are produced by pressure gradients in aerodynamic flow. Since water is incompressible, pressure differences in the channel result in differences in surface height. While the index of refraction is constant, the difference in slope varies the angle of incidence of rays passing through the water surface and, consequently, their angle of refraction. This results in areas of varying light intensities. These show up as highlights or shadows on a ground glass screen.

My experiments so far with the channel have served to familiarize me with the techniques involved. I have observed and studied stalls and other vortex formations.

Working with sub-sonic flow, I have been able to reach Mach 0.57. At this speed, mild shock waves can be observed forming around the cylinder and the airfoil in stall position.

I hope to be able to obtain higher Mach numbers, into the super-sonic range. By means of shadowgraphs, it will then be possible to observe shock wave phenomena on all profiles, and in a fuller range.





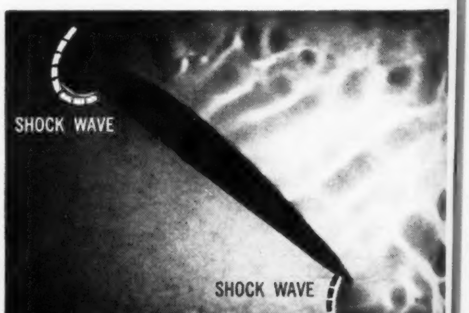


Photo at left shows vortices formed at Mach 0.2. In center photo flow was raised to Mach 0.6, with resulting formation of shock waves. In photo at right, at Mach 0.6 shock waves are seen forming at leading and trailing edge of airfoil.

Meeting the Test

Getting the Most Out of Scientific Reading

By THEODORE BENJAMIN

HERE are two more examples of the kind of "scientific reading" you are likely to meet in many of the newer types of examinations. The subject matter may be unfamiliar, but most of the new words or terms used are defined in each passage. See how well you can do. Read each passage carefully, then answer the questions pertaining to it.

Conduction Through Nerves

The nerve cell or neuron consists of a body and a long thin extension known as the axon which terminates in a nerve ending or terminal arbor. The nerve cell possesses an inner and outer layer. The inner layer contains a high concentration of positively charged potassium ions (an ion is an atom which has lost or gained electrons, thereby taking on an electric charge). The inner layer is surrounded by a sheath which gives the nerve its mechanical strength and acts as an insulator. Outside of this sheath, but within the outer layer, is a liquid very much like sea water, which contains a high concentration of positively charged sodium ions.

When the neuron is stimulated, the sodium and potassium ions interchange positions and set up an electrical current. This process of interchange continues along the axon and constitutes the nerve impulse. The rate at which the reaction proceeds along from one neuron to the next ranges from 2 to 300 feet per second, generally depending on how highly evolved is the particular organism in which the neuron is found. When stimulation ceases it takes at least 3 milliseconds (thousandths of a second) for the potassium and sodium ions to move back to where they were before the impulses. Increasing the intensity of stimulus, rather than causing an increased current, causes a repeated signal to flow; a greater number of "firings" in a given time interval occurring when the stimulus is great.

In the space at the left of each of the following statements write the letter T or F to indicate whether the statement is true according to the information given. Include in your reasoning inferences that may be drawn from the foregoing passage.

__1. A nerve impulse is essentially electrochemical in its nature.

__2. A sodium ion is positively charged because it has gained an electron.

__3. Increasing the intensity of stimulation increases the amount of current traversing the neuron axon.

__4. There is a maximum intensity of neuron stimulation beyond which a further increase in stimulus is not recognized as an increase in intensity.

__5. The velocity of an impulse passing through nerve fibers is greatest in the class of animals known as mammals.

__6. Reflex action is more rapid than thought-out action because, in all probability, the neuron pathway for reflexes is shorter.

__7. Impulses along human nerve fibers travel with the speed of light.

Superconductivity

The phenomenon of superconductivity was discovered in 1911 by Kammerlingh Onnes, a Dutch physicist. Onnes had previously succeeded in liquefying hydrogen at a temperature of 20.4°K (−252.8°C) and liquefying helium at 4.2°K (−269.0°C). He became interested in seeing how the electrical conductivity of metals changed with the lowering of their temperature. He placed wires of various metals into liquid helium and found that, in general, as the temperature of the wire decreased, the resistance to the flow of electric current decreased. For most metals, such as silver, gold, and platinum, the resistance became relatively constant at about 10 degrees above absolute zero; a further decrease in temperature did not further decrease the resistance. When Onnes performed the same experiment with wires of solid mercury, to his surprise at 4.2°K (−269.0°C) the resistance of his mercury wire dropped abruptly to zero and remained there as the temperature lowered. He had discovered the strange phenomenon of superconductivity, whereby a current can flow through the metal with no voltage drop and no heating effect.

With our present ability to reach about 20 millionths of a degree above absolute zero, scientists have discovered that superconductivity occurs in many other metals. Curiously enough, the best conductors at room temperature are not the materials which become superconductors at lower temperatures. In general the normally poorer conductors such as tin, lead, indium, hafnium (you will note that these metals are in the middle range of the periodic chart) become superconducting. To date 22 of the elements are known to be superconductors. The transition temperature, the temperature at which these metals suddenly lose their resistance, varies within a narrow range. The transition temperature for tin is found to be 3.7°K (−269.5°C), and for lead, 7.2°K (−266.0°C). The one with the highest is technetium at 11°K (−262.2°C). Many alloys exhibit superconductivity. In fact, it is possible to alloy two non-superconducting metals like molybdenum and tungsten to form a superconducting alloy. The highest transition temperature known at present is that of a compound of niobium and tin, Nb_3Sn, called niobium stannide, which is superconducting at 18°K (−255.2°C).

__8. 0° Kelvin is equivalent to −273.2°C.

__9. In the superconducting state the resistance of a metal becomes zero.

__10. Copper and aluminum can become superconducting.

__11. Superconductivity as a phenomenon has little technological importance.

__12. Niobium stannide becomes superconducting in liquid hydrogen.

__13. We have discovered metals which are superconducting at room temperature.

__14. Once a current of electricity is started in a loop of superconducting material it should continue to flow forever provided its temperature is maintained below the transition temperature.

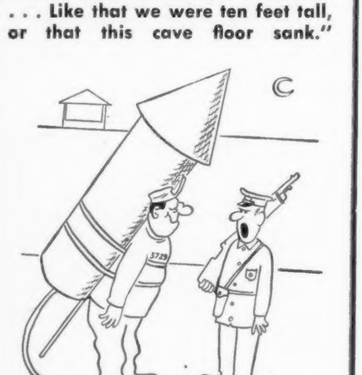
Key to Answers

1-T; 2-F; 3-F; 4-F; 5-T; 6-T; 7-F; 8-T; 9-T; 10-F; 11-F; 12-F; 13-F; 14-T.

Sci-fun

"O.K. . . . *Then* what did you say to the witch doctor?"

"There'll be all kinds of theories. . . . Like that we were ten feet tall, or that this cave floor sank."



"And just *where* do you think you're going?"

Atomic Explorer

(Continued from page 20)

and games, so he made them up for her. By the time she was ten, she had become so interested in his slide rule—an engineer's most useful tool—that he bought her one of her own. To his amazement, she learned to calculate with this mathematical gadget as easily as she had learned arithmetic.

Concert Pianist at 15

"I was always badgering him with questions," Janice remembers. "He answered them carefully but he never tried to push me into a career in science—or any other field. He encouraged my interest in music, too—as he encouraged my twin sister's interest in art." While Judith, the artistic twin, was learning to draw and paint, the mathematically-inclined twin practiced diligently at the piano.

Like most engineers' families, the Buttons moved several times during the years when Janice and Judith were growing up. They were living in Ohio when Janice's musical talent began to be recognized as extraordinary. When she was 15 she appeared as soloist with the Dayton Philharmonic Orchestra, playing the Grieg A Minor Concerto. Her teachers thought she could have a future as a concert pianist.

But young Janice had a mind of her own. At the time of her debut as a concert musician, she had already made up her mind what she wanted to do. She wanted to go to Cornell to study physics and engineering.

Only Girl Graduate in Her Class

When she enrolled in the five-year program at Cornell's School of Engineering, Janice Button was one of four girl students in a class that was, otherwise, all men. She was the only girl to receive an engineering degree at the end of the course, in January 1954. That same year, a Fulbright Fellowship took her to Gottingen University in Germany for more study in physics. In the fall of 1955 she returned to the United States and started to work on her Ph.D. at the University of California. It was there, in 1959, that she joined Drs. Alvarez and Stevenson and their bubble chamber experiment.

Before this experiment, other scientists had identified the invisible track of the lambda hyperon, but only one example of a possible *antilambda* had been observed. Did such a particle exist?

The whole idea of antiparticles is extremely new and just beginning to be understood. The chief distinction between particles and antiparticles is the kind of energy they represent—positive or negative. A particle of *negative* energy also has negative mass and negative momentum. That is one reason why it is so hard to understand. Can you visualize something the *opposite* of mass, moving with the *opposite* of velocity?

Particle physicists like Dr. Button think of empty space as a uniform sea of these negative particles. Now, suppose a hole appears in this negative sea—a hole exactly the size of one particle. Such a hole would be the *absence* of negative mass. This is an antiparticle—a hole in a sea of nothing! But it behaves as if it were something.

An antiparticle may be difficult to imagine, but it is quite real. Dr. Button can't see the antilambda hyperon, but she knows when one has passed through the bubble chamber. What's more, she knows how fast it was going and how to measure its mass. Here's how it works:

Detective Work on the Atom

The process begins with the Bevatron, the University of California's powerful particle accelerator that uses tremendously high electrical voltages to produce charged particles. An energy level of six billion electron volts (6 Bev) is needed to produce a beam of antiprotons. This beam is directed by magnets into the bubble chamber. As an antiproton passes through the chamber, it bumps into a hydrogen atom and interacts to form two new particles, the lambda and antilambda hyperons.

The bubble chamber is filled with liquid hydrogen. At room temperature and ordinary pressure the hydrogen would be a gas, but in the chamber it is kept very cold (more than 400 degrees below zero F.) and under tremendous pressure. Under these conditions, the hydrogen behaves like a liquid.

Now, when a particle with an electrical charge passes through the liquid hydrogen, it knocks electrons off the atoms in its path, leaving a trail of *ions*.

When the pressure on the liquid hydrogen is suddenly relieved, the liquid vaporizes. It becomes superheated—actually boiling. Bubbles form along the ion trails left by any particles passing through. These tracks can be photographed. When Dr. Button studies the photographs, she can identify particles which have passed through by the pattern of the bubble tracks.

And now comes the clever detective work. Lambda and antilambda particles leave no tracks. How does she identify them?

Both lambda and antilambda hyperons are "heavy" particles—heavier

than a proton. Heavy particles tend to decay—or split up—soon after they come into being. In the case of the anti-lambda particle the lifetime is, you will remember, 2.7×10^{-10} seconds. During this brief lifetime the particle leaves no tracks. Then it splits into two particles which do leave tracks—an antiproton and a pi meson with a plus charge. These particles travel away from each other in paths that form a curved V. This is the clue Dr. Button is looking for. By measuring the *angle* between the two paths and certain other characteristics she can identify the invisible particle. The angle is its "fingerprint."

Playing nursemaid to a bubble chamber keeps the pretty physicist busy. "While the experiment is running," she told us, "I spend every day in the lab—even Saturdays and Sundays. And I return to the lab at least three nights a week."

This full schedule doesn't leave much time for social activity—or just plain rest. But Dr. Button occasionally finds time to accept a date for skiing or swimming. Sometimes she entertains a few friends at dinner. "I like to cook," she said, "when it's not just for me."

A pair of silver earrings, shaped like musical quarter notes, reflect her continuing interest in music. "I still play, but mostly just for relaxation," she confided. "I don't play in public any more." Her twin sister, Judith, has kept up her interest in art, but her career has followed a different path. She's married to a lawyer and is learning how to manage a 17-month-old son.

Marriage—and Career

Dr. Button hasn't ruled out the idea of mixing marriage with her career as a physicist. "It wouldn't be easy, but I think it could be done," she said. "I've noticed that women in science usually drop their careers as soon as they marry. This isn't *always* the case—in our lab there is a married woman physicist with a child—but she is an exception. The big difficulty is in keeping up with new developments. In some other fields, a woman may stop working for a few years, until her children start to school, then pick up her career again. But in the sciences, five years away from a field can be too much. Even working full time as a physicist, I find that I have to take a few courses every year, to read considerable literature, and to talk to other people in the field."

She has no plans for marriage—just yet. "If I do marry," she speculated, "he'll probably be a scientist. And I would rather help my husband with his experiments than to originate experiments of my own."

—Barbara Land

Genes and Mutations

(Continued from page 11)

Thus we can tell how often a gene target is hit, and knowing the length of the chromosome and the density of the X-ray particles, we can estimate the size of the gene. After many repetitions of these and other equally indirect methods of measurement, the gene has been estimated at between 10 and 100 millimicrons in diameter. (A millimicron is 10^{-6} millimeters.)

Genes, Enzymes, and Reactions

What do genes really do?

These tiny particles, in interaction with the environment, are responsible for a great deal of our physical, emotional, and mental makeup. Hair color, skin color, facial characteristics, mental capacity, and even our size are given limits by the genes. In the same way, the color of flowers, the sweetness of watermelons, the coloring on a butterfly's wings, and the silvery flash of a minnow's back are in large part regulated by the genetic makeup of each of these organisms.

But how does the gene do these things?

In one sense a living organism is a system of chemical reactions. For example, your body consumes sugar for energy; your breakfast eggs become human protein for growth. Biologists specializing in the chemistry of life have found that the chemical reactions of living things are influenced by the presence of enzymes. These are chemicals that may speed reactions, or regulate them in other ways, without themselves taking part in the reaction. Biologists theorize that for every necessary chemical reaction in the body there is a specific enzyme.

As the egg differentiates and forms various specialized tissues in the embryo, many chemical reactions are involved. These reactions are so complex that scientists have very few clues as to how they take place. On the basis of their knowledge of the reactions involved in digestion and energy use in living tissue, scientists assume that the chemical reactions involved in differentiation also require enzymes. In differentiation, they theorize, genes enable the required enzyme to function at the proper time.

The work of Dr. George Beadle and Dr. Edward L. Tatum supports this theory. Working with the red bread mold, Neurospora crassa—an organism as useful to geneticists as Drosophila—these scientists have shown that relationship exists between genes, enzymes, and life-supporting chemical reactions.

The bread mold is a much simpler organism than Drosophila, and its chemical reactions are easier to observe. Its requirements for life are simple. Apart from sugar, the only substance it needs (which it cannot supply by itself) is a vitamin called biotin.

Dr. Beadle and Dr. Tatum set to work irradiating the mold with X rays in an attempt to induce mutations. Their goal: To produce mutant strains that differed from normal strains in some simple nutritional requirement. They succeeded in producing a strain of mold that failed to grow on ordinary media. The spores from this mutant strain were then grown on media containing many varieties of nutrients. After 299 experiments, Dr. Beadle and Dr. Tatum found that vitamin B-6, an enzyme, was the missing ingredient needed by the mutant mold to make it grow. Their conclusion: X-ray irradiation changed the gene that produces vitamin B-6 in normal molds.

When the mutant strain was mated with a normal strain, the need for vitamin B-6 was transmitted to the offspring, just as Mendel found that tallness in pea plants was transmitted. From these and similar experiments by other investigators, there is good evidence to believe that genes produce their effects by controlling the production of specific enzymes for the chemical activity of life.

Mutations—Good and Bad

From the work of Dr. Muller in 1928 (who won the Nobel Prize in 1946), down to the work of Dr. Beadle and Dr. Tatum (who were Nobel Prize winners in 1958), X rays have played an important part in the investigation of genes.

The high speed particles of X rays, however, are not the only kind of radiation that may produce gene mutations. It is known that ultraviolet and gamma radiation also cause mutations. It is thought that the many mutations occurring in nature may be the result of radiation from natural sources, such as cosmic radiation or radiant energy from the sun. These mutations, depending upon the environment, may be detrimental to the organism or of value to it.

If surviving mutants of value for the species can be produced by nature, scientists reasoned, it should be possible to produce them experimentally. At the Brookhaven National Laboratory in New York, there is now in progress an extensive program investigating gene mutations in plants grown in a field exposed to gamma radiation from radioactive isotopes.

Mutations that occur in the genes of the egg and sperm cells can be passed to following generations. But genes are

(Continued on page 31)

BRAIN TEASERS

Nervous Fly

Imagine two trains leaving different railroad stations, 300 miles apart, at the same time. The tracks between the railroad stations are in a straight line. There is a fly on the headlight of one of the trains, and when the train starts to move, the fly takes off and flies directly to the headlight of the other train, flying at 100 mph. The fly flies at this speed back and forth between the headlights of the two trains until the trains meet. If one train is traveling at 70 miles per hour, and the other at 80 miles per hour, how much distance will the fly cover before the trains meet? This problem is simpler than it seems.

Richard Macomber
Hudson High School
Hudson, Mass.

Answer: The trains are traveling toward each other at the rate of 70-plus-80, or 150 miles per hour. That means that in two hours the trains will have covered 300 miles, and will meet. Since the fly is constantly traveling at 100 miles per hour, after two hours it will have covered a total distance of 200 miles.

Explorer's Jeep

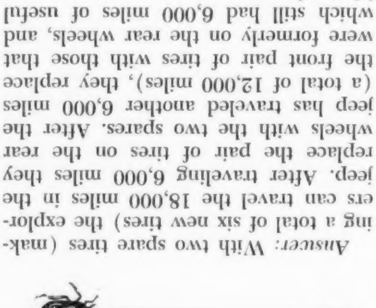
"Nice new jeep," said an explorer, affectionately patting his car, "and it's got some tall rolling to do. According to my calculations, we've got 18,000 miles of driving ahead."

"Let's see," mused the second explorer, "these brand new tires are rated to last exactly 12,000 miles on desert terrain. If we get the full mileage out of each tire, how many spares will we need to carry us over the entire 18,000 miles?" After some thought, both explorers arrived at a simple solution. What was it?

Tom Kubiak
St. Stanislaus High School
Bay City, Michigan

Answer: With two spare tires (making a total of six new tires) the explorers can travel the 18,000 miles in the jeep. After traveling 6,000 miles they replace the pair of tires on the rear wheels with the two spares. After the jeep has traveled another 6,000 miles (a total of 12,000 miles), they replace the front pair of tires with those that were formerly on the rear wheels, and which still had 6,000 miles of useful life in them.

Can you think of other arrangements? Could the explorers finish the trip if they carry only one spare tire?



Bug Chase

Four bugs—A, B, C, and D—occupy the corners of a square 10 inches on a side. Simultaneously, A starts crawling directly toward B, B toward C, C toward D, D toward A.

If all four bugs crawl at the same rate, where will the bugs meet, and how far will they have traveled?

Tim Scott
Fairborn, Ohio

Answer: Since all the bugs crawl at the same rate, each bug approaches the other at the same rate. Therefore, since they started an equal distance apart, the bugs will always remain an equal distance apart. This means that at any given moment the four bugs will always form the corners of a square, which shrinks and rotates as the bugs move closer together. Since the bugs always form the corners of a square, the pursued bug is always moving at right angles to its pursuer. For instance, B is always moving at right angles to A. This tells us that there is no component in B's motion that carries B toward or away from A. Therefore A will capture B in the same time that it would have taken if B had remained stationary at the corner of the original square. The distance A travels will, therefore, be the same as the length of the side of the original square, or ten inches. (It can be shown mathematically that the actual path taken by each bug is a logarithmic spiral.) Since each bug travels a similar spiral, they must all meet in the center of the square.

Clever Cook

Mr. Cook, Mr. Sailor, and Mr. Carpenter met on the street one afternoon. "Isn't it strange," said Mr. Cook to the others, "that not one of us has a profession the same as our name?"

"That's true," agreed the man who was the carpenter.

Can you name the profession of each one of the men?

Dominic Piacenza
Bulkeley Junior High School
New London, Conn.

Answer: Mr. Cook cannot be the cook, since his profession cannot match his name. Mr. Cook cannot be the carpenter, because the carpenter replied to Mr. Cook's question. So Mr. Cook must be the sailor. Mr. Carpenter cannot be the carpenter or sailor, so he must be the cook. This leaves Mr. Sailor, who must be the carpenter.

Send in Your Favorite Brain Teaser

You surely have a favorite brain teaser that you would like to share with other readers. Send the brain teaser, together with the solution, to Science World, 33 *West 42nd Street, New York 36, N. Y. We will pay $5 for every brain teaser published. Include the name of your school, in addition to your home address, and state your age.*

Machines That Listen

(Continued from page 15)

vidual notes or instruments can then be combined and re-recorded to make even more complicated instrumental and orchestral effects. Entertainers such as Les Paul have used re-recording to make a single record in which they appear to play all the different parts of a musical composition simultaneously.

To test the Synthesizer, its designers used piano and violin compositions recorded by famous artists. The tone structure of these compositions was completely analyzed, and this information was then fed to the Synthesizer. The machine went to work and recorded its own performance of each musical composition. When the synthesized version and the original version were played to a panel of listeners, only one listener in four could identify which was which.

The Electronic Music Synthesizer can create music beyond the limitations of musicians and instruments. It can create tones different from those made by any existing instrument. Where a musician's performance is limited by his ten fingers, two hands, two feet, or lips, the Synthesizer can simulate any combinations of fingerings or positions possible on an instrument. For example, the Music Synthesizer could play a piano piece for 33 fingers, if such a piece were composed.

The Electronic Music Synthesizer will never replace the symphony orchestra, however. It takes human artists to compose and interpret the music for it to have human significance. The Synthesizer can play only the music its designers tell it to play, just as Audrey can hear only the sounds its designers have wired it to hear. Only a human being can give a robot purpose, or make its work meaningful.

Answers to Crossword Puzzle

(See page 30)

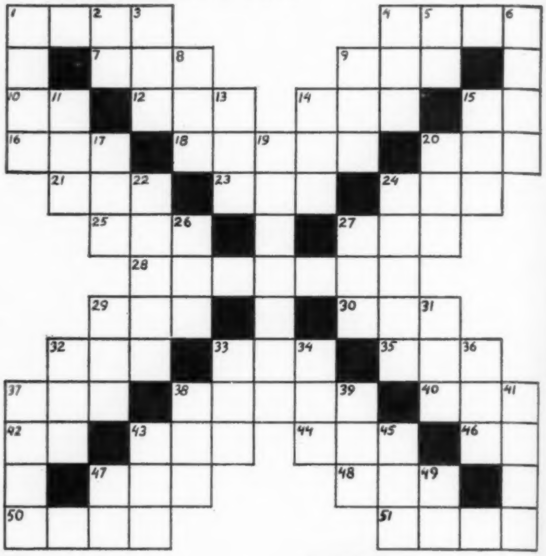
H	A	H	N						R	A	Y	S
E	█	E	A	R				S	A	M	█	A
B	R	█	G	A	S		I	O	W	█	E	M
E	A	T	█	N	O	C	K	S	█	O	R	E
	H	O	T	█	D	O	E	█	G	A	R	
		E	R	A	█	U	█	R	A	T		
			U	R	A	N	I	U	M			
		A	S	K	█	T	█	E	M	S		
	A	R	T	█	V	E	T	█	A	T	E	
A	G	E	█	M	A	R	I	E	█	Y	E	T
N	O	█	I	O	N		E	O	S	█	L	U
N	█	T	U	B				N	O	D	█	N
A	T	O	M						B	E	T	A

Molecules in Motion

By Norman Masse, Montreal (Quebec) High School

★ Starred words refer to physics

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzle cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 29.



ACROSS

- * 1. German scientist who experimented with uranium.
- * 4. Roentgen ______ were discovered in 1895.
- 7. Hearing organ.
- 9. Man's name.
- *10. Element of atomic No. 35 (*symbol*).
- *12. Molecules can move and expand freely in this state of matter.
- 14. Isle of Walcheren (*abbr.*).
- *15. American physicist, winner of 1951 Nobel Prize (*initials*).
- 16. Devour.
- 18. The notched parts of arrows that hold the bow string.
- 20. Natural state of metal.
- *21. Molecular energy is greatly increased when a metal becomes ______.
- 23. Female deer.
- 24. Grand Army of the Republic (*abbr.*).
- 25. "______ of Good Feeling," 1817-1824.
- 27. Rodent.
- *28. Element used in nuclear fission.
- 29. Request.
- 30. Printer's measures.
- 32. Skill.
- 33. Animal doctor.
- 35. Had supper.
- *37. The Atomic ______, 1945-?.
- *38. Mme. Curie's first name.
- 40. Adverb meaning still, besides.
- *42. Symbol for man-made element No. 102.
- *43. Electrically charged atom.
- 44. Goddess of the dawn.
- *46. Element of atomic No. 71 (*symbol*).
- 47. Large basin.
- 48. Shake one's head.
- *50. Basic particle of fission.
- *51. Negatively charged particles that appear identical with cathode rays.

DOWN

- 1. Greek goddess of youth, daughter of Hera and Zeus.
- * 2. The most difficult of all gases to liquefy (*symbol*).
- 3. To scold continually; to pester.
- 4. Uncooked.
- * 5. Man-made element No. 95 (*symbol*).
- 6. Alike.
- 8. Moved quickly.
- 9. Distress signal.
- 11. A cheer.
- 13. Turf.
- 14. President of U. S. (*nickname*).
- 15. Make a mistake.
- 17. Pedal digit; part of the foot.
- *19. Geiger Mueller ______.
- 20. A cereal grass.
- 22. Confidence.
- *24. Ray emitted during fission.
- 26. Noah's ______.
- 27. Street (*French*).
- 29. Measure of area in the metric system.
- 31. Pig pen.
- 32. In the past.
- *33. ______ de Graaf generator, a particle accelerator.
- 34. Bind.
- 36. Snake-like fish.
- 37. Girl's name.
- 38. A large disorganized group.
- 39. An age, usually of immense duration.
- 41. Edible fish.
- *43. Suffix which denotes metallic elements.
- 45. Weep.
- 47. Preposition.
- 49. Of (*French*).

Genes and Mutations

(Continued from page 27)

present in all cells, and these genes are particularly susceptible to mutation during cell division. Young growing plants undergo rapid cell division and mutations are likely to occur if they are exposed to radiation. Mutations occurring in cells other than the reproductive cells are called *somatic* or body cell mutations. These mutations are not hereditary. Many of the interesting results produced in the gamma field at Brookhaven are due to such somatic mutation.

Nuclear radiation can rearrange the structure of molecules. The genes, made up of molecules, are subject to change under radiation. Thus the characteristics controlled by a gene could be changed. There is no way at present to predict whether this change would be beneficial or harmful.

In the past ten years, the Brookhaven research has produced many new and useful varieties of plants resulting from gene mutations, as well as many grotesque types. Among the useful ones are disease resistant oats, wheat with increased grain weight, early ripening soy beans with increased yield, and barley with higher protein content. At Brookhaven they have even changed a white carnation to red by somatic mutation.

Genes, Radiation and the Future

What will be the effect of atomic radiation on human genes?

Some mutations in human genes are known to be harmful. For example, one type of mutation results in the loss of a chemical that enables blood to clot. A person without this chemical might bleed to death. Another harmful mutation is one that causes babies to be born without hands or feet. On the other hand, it is possible that some mutations in human genes may be favorable, just as they are in plants. It is possible that a mutation may improve eyesight or give added resistance to a specific disease.

In commenting on this question, Dr. Theodosius Dobzhansky of Columbia University, a world-renowned geneticist, has written, "What proportion of mutants arising in man, with or without exposure to atomic radiations, belongs to one or the other of these classes [harmful or beneficial] is entirely an open question at present."

Scientists are agreed that atomic radiation may have harmful effects, but the very fact that they are aware of this is a hopeful note. The rapid progress of research and our rapidly increasing knowledge of genetics give hope that the scientific benefits resulting from atomic radiation may far outweigh its harmful effects.

Coming in the Next Issue

Why do we have 50-foot tides in Nova Scotia's Bay of Fundy, while a few hundres miles south, at Nantucket Island, the water rises but one foot? "The Wonder of the Tides" explores these mysteries of the sea.

How have scientists measured the speed of light? What do we know about the nature of light? Is it made up of waves or particles? Or of particles in wave-like motion—"wavicles"? See Michael Dadin's article.

Organisms are found from the depths of the sea to the peaks of mountains. Some thrive in tropic heat, others in polar cold. What enables organisms to adapt to environment?

Plus a "Today's Scientists" interview with Dr. Walter H. Brattain, the scientist who helped to develop the transistor.

Plus research reports from a pair of "Tomorrow's Scientists."

Plus all the other features.

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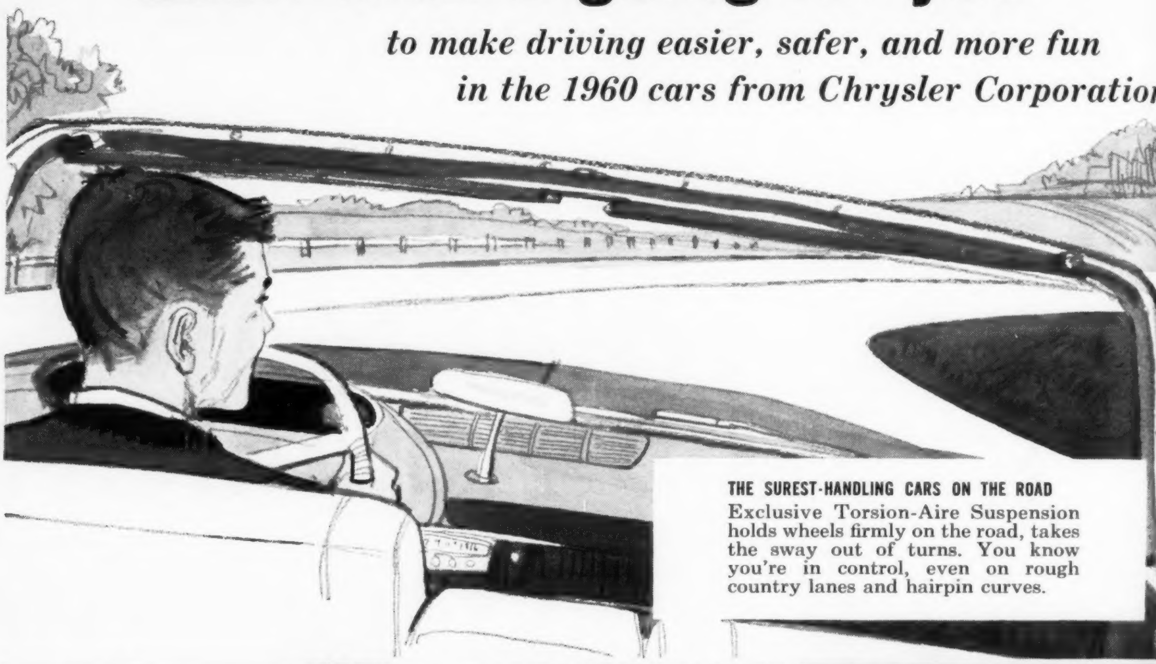

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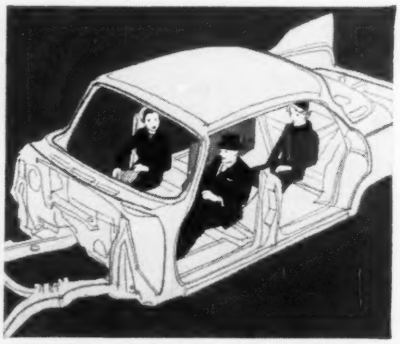

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The article also makes it quite evident that modern biology calls on all the scientific disciplines and requires aid from mathematics in the form of statistical procedures. The final answer to the problems of life, its continuity and origin, will be unraveled by the biochemist, the physicist and the mathematician working in concert.

The closing paragraphs, dealing with the problems of radiation and mutation, offer a chance to make science meaningful in the life of the student by relating biology to a problem of immediate and international concern.

Topics for Discussion and Reports

1. Reports on the work of Mendel, Morgan, Muller, Tatum, and Beadle.
2. Reports on the experimental plants and animals and their suitability for genetic research: Drosophila, Neurospora crassa.
3. The application of genetics in agriculture and animal husbandry.
4. Discussion of theory and hypothesis.
5. Discussion of radiation hazards, followed by an analysis to identify emotional content vs. informed content based on acceptable data. —W. D.

More Help for Physics Teachers

High school physics teachers interested in improving both content and instructional methods are due to receive help from the American Institute of Physics.

The institute, which represents the leading physical societies in the country, will send 150 physicists into the high schools as consultants. Their aim: to increase the number of students enrolled in physics courses by modernizing the content of high school physics and by emphasizing the need for stimulating lab work. By these methods they hope to make physics attractive and stimulating to high school boys and girls.

The present campaign is directed at educating local school boards and administrators in the importance of physics as part of the basic high school curriculum. With this aim in view, the institute has issued a 136-page handbook, *Physics in Your High School.*

The booklet represents one of the first attempts of a scientific society to inform the general citizenry about what is and what is not important in teaching high school physics. The booklets will be distributed to mayors, and leading citizens as well as board members and administrators.

Among the recommendations of interest to physics teachers are the following:

Salaries of high school science teachers should be on a par with scientists in industry. There should be extra pay for extra work.

College - bound physics students should study mathematics as a way of thinking—not as a bag of tricks merely useful in solving problems.

A physics class should consist of not more than 25 pupils.

Physics is essential to general education in the modern world. The parochial and disfunctional view that physics is primarily for the college-bound student with a career interest in science or engineering should be eliminated from educational planning. The handbook states that "we must carry on experimentation with physics courses geared to the interests, needs and abilities of pupils of moderate ability . . . an understanding of the fundamentals of physics is important to all."

If you write to the institute at 335 East 45th Street, N. Y. 17, the handbook will be sent to your board members and administrators.

Summer Institutes for Elementary Science Teachers

Recognizing that science education begins in the elementary school, the National Science Foundation has provided funds to support 15 summer science institutes for elementary school teachers, supervisors, and principals.

Primary emphasis of the institutes will be on strengthening the participants' mastery of basic concepts in science and mathematics. This experimental program will provide financial assistance to 550 supervisors, principals, and experienced teachers.

The foundation grant is made to the college or university supporting the institute. The colleges select eligible students and determine the amount of financial aid available to each. The maximum stipend is $75 a week, which may be augmented with a dependency allowance of $15 a week per dependent up to four. Thus a teacher with a wife and two children could expect to receive, in addition to full tuition and fees, $120 per week while attending the institute.

The announcement of the institutes cautions teachers against applying directly to the National Science Foundation. Applications are available from the host school only and *not* from the National Science Foundation. Completed applications must be postmarked by March 15 to insure consideration.

The following colleges and universities are sponsoring elementary science institutes. Interested teachers should apply without delay to the official listed:

TEACHERS COLLEGE, COLUMBIA UNIVERSITY (6-week course), *Earth-Space Science, Matter and Energy; Modern Biological Concepts;* for key teachers, supervisors, and science specialists. Prof. F. L. Fitzpatrick, Teachers College, Columbia University, New York 27, New York.

DePAUW UNIVERSITY, 6 weeks, *General Science; Mathematics;* for teachers (grades 5-6) and supervisors. Dr. Donald J. Cook, Chemistry Department, DePauw University, Greencastle, Indiana.

UNIVERSITY OF KANSAS, 8 weeks, June 13–August 6: *Biological Science; Physical Science;* for teachers, supervisors, principals, and demonstration teachers in laboratory schools. Dr. Robert W. Ridgway, 101 Bailey Hall, University of Kansas, Lawrence, Kansas.

LONGWOOD COLLEGE, 4 weeks, July 6–August 3: *Mathematical Concepts Basic to Arithmetic; the Modern Arithmetic Program;* for supervisors and supervising principals. Dr. Blanche C. Badger, Department of Mathematics, Longwood College, Farmville, Virginia.

NORTHERN ILLINOIS UNIVERSITY, 8 weeks, June 20–August 12: *Fundamentals of Chemistry and Physics;* for teachers (grades 4-6), science supervisors, and principals. Dr. Frederick W. Rolf, Department of Chemistry, Northern Illinois University, De-Kalb, Illinois.

NORTHERN MICHIGAN COLLEGE, 6 weeks, June 20–July 29: *Astronomy; Meteorology; Geology;* for teachers (grades 1-8), supervisors and principals. Dr. Henry Heimonen, Department of Geography, Northern Michigan College, Marquette, Michigan.

UNIVERSITY OF RHODE ISLAND, 6 weeks, July 5–August 12: *Ecological Background of Natural History;* for teachers (grades 5-6), and supervisors (grades 5-6). Dr. Victor H. Hutchison, Department of Zoology, University of Rhode Island, Kingston, Rhode Island.

RUTGERS-THE STATE UNIVERSITY, 6 weeks, July 5–August 12: *Earth Science;* for teachers and science supervisors. Prof. Guido G. Weigend, Chairman, Department of Geography, Rutgers-The State University, New Brunswick, New Jersey.

THE COLLEGE OF SAINT CATHERINE, 6 weeks, June 20–July 29: *Mathematical Backgrounds of Arithmetic; Structural Concepts of Mathematics; Topics from Modern Mathematics;* for teachers (grades 5-6) and principals. Sister Seraphim, The College of Saint Catherine, St. Paul 5, Minnesota.

SAN FERNANDO VALLEY STATE COLLEGE, 6 weeks, June 27–August 6: *Physical Science;* for teachers (grades 1-8), supervisors, and principals. Prof. Ruth L. Roche, Division of Education, San Fernando Valley State College, Northridge, California.

SAN JOSE STATE COLLEGE, 6 weeks, June 20–July 29: *Foundations of Arithmetic; The Expanding World of Arithmetic; Theory and Practice in Teaching New Topics in Arithmetic;* for teachers and supervisors of elementary school arithmetic. Prof. James R. Smart, Mathematics Department, San Jose State College, San Jose, California.

UNIVERSITY OF SOUTH CAROLINA, 6 weeks, June 13–July 23: *Physical Science;* for teachers (grades 4-6), supervisors, and principals. Dr. Frederick H. Giles, Jr., c/o School of Education, University of South Carolina, Columbia, South Carolina.

SOUTHERN UNIVERSITY, 8 weeks, June 6–July 29: *Field Biology and Ecology;* for teachers (grades 4-7). Dr. Woodrow H. Jones, Department of Biology, Southern University, Baton Rouge, Louisiana.

Biology Course on Film

A complete and widely pre-tested high school biology course in color motion pictures will be available for use in American classrooms next September.

Planned by the American Institute of Biological Science, and in production for more than two years, the film series embodies content recommended and approved by nearly 200 of the leading contemporary biologists and by professional organizations representing the great majority of America's practicing biology teachers.

The course employs modern instructional media, including inserts showing prominent guest lecturers, visits to leading biological laboratories and field stations, portions of outstanding American and foreign research films. A wide range of photographic techniques including cinemicrography, still photographs, and animated sequences were used to provide teaching effectiveness.

A total of 120 lecture demonstration type films, each 30 minutes long, makes up the course. The complete package of 120 may be used for a full year of high-quality instruction. Smaller units of 12 films on major areas of biological knowledge, or individual films on specific subjects, also will be available to teachers to meet individual needs.

While a small school without a qualified biology teacher or facilities for biology instruction might use the series to advantage, the course is planned for presentation to the student with four principal components—his own teacher, the films, a Teacher's Manual, and a Study Guide. The last two items are provided as part of the AIBS film course.

Throughout the AIBS course the emphasis is on modern biology. Recent advances in radiation biology are stressed. Recurring themes include the complementarity of structure and function, the "organization" aspects of living forms, energy flow in living systems, homeostasis, evolution, and ecology. Also stressed are man's role in nature, and behavior as a phenomenon unique to life—and biology as an open-ended science with abundant challenge.

The film series was prepared with the support of the Fund for the Advancement of Education of the Ford Foundation and the Atomic Energy Commission. Robert B. Lewis, science supervisor of Aspen, Colorado, schools, served as consultant for film demonstration materials.

Information about the series may be obtained from the publisher of the films, Text-Film Department of the McGraw-Hill Book Company, Inc., 300 W. 42nd St., New York 36, N. Y.

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